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MONTHLY WEATHER REVIEW

VOLUME 48, No. 9

SEPTEMBER, 1920

WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

INTRODUCTION.

The MONTHLY WEATHER REVIEW contains (1) meteorological contributions, and bibliography including seismology; (2) an interpretative summary and charts of the weather of the month in the United States and on the adjacent oceans; and (3) climatological and seismological tables, dealing with the weather and earthquakes of the month.

The contributions are principally as follows: (*a*) Results of the observational or research work in meteorology carried on in the United States or other parts of the world, in the Weather Bureau, at universities, at research institutes, or by individuals; (*b*) abstracts or reviews of important meteorological papers and books; and (*c*) notes. In each issue of the REVIEW abstracts, reviews, and notes are grouped by subjects, roughly, in the following order: General work, observations, and reductions, physical properties of the atmosphere, temperature, pressure, wind, moisture weather; applications of meteorology, climatology, and seismology.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but **the publication of contributions is not to be construed as official approval of the views expressed.**

The partly annotated bibliography of current publications is prepared in the Weather Bureau Library. *Persons or institutions receiving Weather Bureau publications free should send in exchange a copy of anything they may publish bearing upon meteorology, addressed "Library U. S. Weather Bureau, Washington, D. C.,"* in order that the monthly list of current works on meteorology and seismology may be as complete as possible. Similar contributions from others will be welcome. Bibliographies of selected subjects are published from time to time in the REVIEW OR SUPPLEMENTS.

The section of the weather of the month contains (1) an interpretative discussion of the weather of North America and adjacent oceans and some notes on the weather in other parts of the world; (2) details of the weather of the month in the United States; and (3) brief discussions of weather warnings, rivers and floods, and weather and crops. There are illustrative charts. The climatological tables comprise summaries of the weather and excessive precipitation data for about 210 stations in the United States, and summaries of the weather observed at about 30 Canadian stations.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are due especially to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
Meteorological and Seismological Service of Mexico.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The seismological tables contain, in a form internationally agreed on, the earthquakes recorded on seismographs in North and Central America. Dispatches on earthquakes felt in all parts of the world are published also.

Since it is important to have as the name of the month appearing on the cover of the REVIEW that of the period covered by the weather discussions and tables rather than that of the month of issue, the REVIEW for a given month does not appear until about the end of the second month following.

SUPPLEMENTS, containing kite observations, and others containing monographs or specialized groups of papers, are published from time to time.

NOTES TO CONTRIBUTORS.

Authors are requested to accompany their papers submitted for publication with a brief opening synopsis. When an article deals with more than one subject—as, for example, a method of measurement, some experimental results and a theory—each subject should be summarized in a *separate paragraph*, with a title which clearly describes it.

When illustrations accompany an article submitted for publication in the MONTHLY WEATHER REVIEW, the places where they should appear in the text should be indicated, and legends or titles for them should be inserted just after the end of the article. As far as practicable the illustrations when accompanied by their legends should be self-explanatory—i. e., the data on them should leave no doubt of what they are intended to convey.

BACK NUMBERS OF THE REVIEW WANTED.

The Weather Bureau has not enough of the following numbers of the MONTHLY WEATHER REVIEW to meet even urgent requests for filling up files at institutions where the REVIEW is constantly being referred to. The return of any of these or of any 1919 or 1920 issues, especially November, 1919, will be greatly appreciated. The attached addressed franked slip may be used for this purpose, or one may be had on application to the Chief, U. S. Weather Bureau, Washington, D. C.

1914: January, February, March, April, September, October, December.
1915: May, June, July, August.
1916: January, August.
1917: June.
1918: February, September.
1919: Any issue, especially November
1920: Any issue, especially January.

SUPPLEMENT, No. 3.

MONTHLY WEATHER REVIEW

CHARLES F. BROOKS, Editor.

VOL. 48, No. 9.
W. B. No. 721.

SEPTEMBER, 1920.

CLOSED NOV. 3, 1920
ISSUED DEC. 8, 1920

SOME FURTHER USES OF THE CLIMOGRAPH.

By B. M. VARNEY.

[University of California, Aug. 2, 1920.]

SYNOPSIS.

The climograph as developed by Dr. Griffith Taylor, but in a modified form in which data for air temperature and relative humidity are used in place of those for wet-bulb temperature and relative humidity, is believed to be useful in many ways beyond the simple showing of monthly averages of climatic conditions as heretofore. In demonstration of this, four climographs (in addition to one using monthly averages) are given, three of them in a comparison of certain details regarding the climates of San Francisco and Fresno, Calif., the fourth to illustrate the climographic representation of a hot wave. Suggestions are made as to the usefulness of the climograph in depicting nonperiodic weather changes in general. The emphasis is on its value as a supplement to the conventional curve, as a help to the visualizing as far as possible of the *effects* of climate and weather on organic life.

The climograph, as a device for setting forth and interpreting climatic data, is not new. Dr. Griffith Taylor of the Australian Bureau of Meteorology showed some of its great possibilities in his paper on the Control of Settlement by Humidity and Temperature.[1] Since the publication of Taylor's paper other investigators have called attention to the climograph. It is the belief of the present writer that this device, used either in connection with the better established graphic methods, or by itself, is so powerful a means of putting vitality into the somewhat lifeless mass of climatic data (the interpretation of which is the climatologist's major business) that it merits further discussion.

One scarcely need point out the great usefulness, to the geographer, the business man, the physician, the teacher, of any device which helps to create living conceptions of the nature of climate and weather, so leading to a better estimate of the effect of a given atmospheric environment on human affairs. One suggestion will suffice. A physician, asked for his opinion on the desirability of a certain place from the point of view of its climate, may get sheaves of data from the Weather Bureau. From these, he can, if he has time and inclination, plot curves and arrive at a conclusion as to the probable physiological effects of the climate in question. But the probability is that, for all his pains, his conception of that climate will fall short of being an adequate basis of advice to his patient. Nobody is to blame for this (unless it be the climatologist). It is a case of a certain incompetency of the interpreting devices. This statement is not for a moment intended to belittle the fundamental value of curves plotted from data. But, however striking these may be, it is to be questioned if they enable us to interpret climate in terms of its effect on human affairs as well as some other device. No graphic device ever can fully do that. The climograph, however, is adaptable to expressing very many of the facts of climate and weather. Its use hitherto has been limited to the expression of monthly values. The object of this note is to point out its quite extraordinary usefulness in other ways.

Dr. Taylor in his climographs used the wet-bulb temperature and the relative humidity. This combination seems to the writer and others to suggest perhaps too much emphasis on the moisture element and too little on that of air temperature, for the reason that both are expressions of the actual to the possible moisture content of the air. The "sensible temperature" with wet bulb at 70° F. and the dry bulb at 71° F. is a vastly different thing from that with wet bulb at 70° F. and dry bulb at 85° F. In the climographs here presented, therefore, the values of *air temperature* and *relative humidity* are used,[2] those two factors being probably of greatest importance in determining the reactions of animal and plant life to atmospheric environment. This modification of Taylor's method of constructing the climograph, while it is believed to be an improvement, certainly does not minimize the essential value of the device as developed by him.

I have selected for illustration certain items in connection with two strikingly divergent types of California climate, those of San Francisco and of Fresno. San Francisco is almost entirely under a climatic régime typical of a cool windward coast in the subtropical belt. Fresno, in the middle of the broad and flat San Joaquin Valley, separated from the cooling influences of the ocean, has a climate which is in many respects of an extreme continental type, in the same belt. Without the aid of graphic devices, the resulting conditions can be somewhat vaguely pictured. For San Francisco, one thinks at once of moderate temperatures and moderate temperature ranges, high relative humidity, considerable sameness through the year. For Fresno, wide differences of temperature and relative humidity, ranging from very hot and dry to rather cold and damp—a climate of distinct variability. But what are the actual details, and how are they likely to affect health, or business? Such further questions as these must be answered: What is an average day like in July, or January, or some other month? Would a person in delicate health find the early forenoons too cold and damp to be out in? How do the conditions during the heat of the day vary through the year? Are the evenings cool and comfortable? Not long since the writer was asked for certain climatic data by a firm engaged in the producing and marketing of cider. The location of new distributing points was to be decided upon partly on the basis of the thirst-provoking qualities of the climate in various parts of California. Climographic evidence was brought in and proved immensely instructive to the inquirer.

Figure 1 is given by way of expressing the broad facts about the two climates suggested above. The climograph shares with the conventional curve the disadvan-

[1] Commonwealth Bureau of Meteorology, Bull. No. 14, Melbourne, 1914. See also a review by Huntington in Geog. Review, Vol. IV, No. 5, November, 1917, pp. 401–403. See also MONTHLY WEATHER REVIEW, December, 1917, 45: 589–590, and July, 1919, 47: 490–495.

[2] This combination was first used by Dr. John Ball: see MONTHLY WEATHER REVIEW, July, 1919, 47: 494, and May, 1920, 48: 279.

tages that arise if one attempts to create a conception of a climate in terms of monthly averages, for these give little hint of how wide ranging may be the values entering

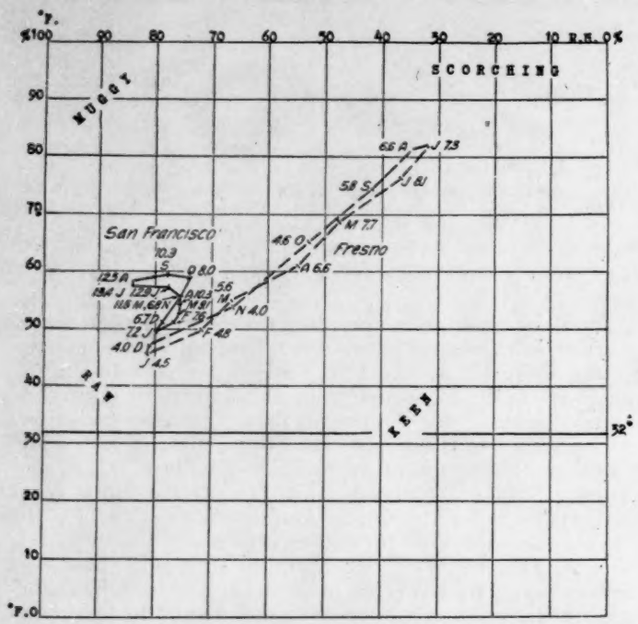

FIG. 1.—Climograph of monthly averages of air temperature and relative humidity at San Francisco and Fresno, Calif. Figures near the initial letters of the months show mean monthly wind velocity in miles and tenths.

them. The remaining figures, then, show the climograph as an interpreter of the more detailed facts.

In figure 2 is pictured the character of the average day at Fresno for two selected months. One's conception of

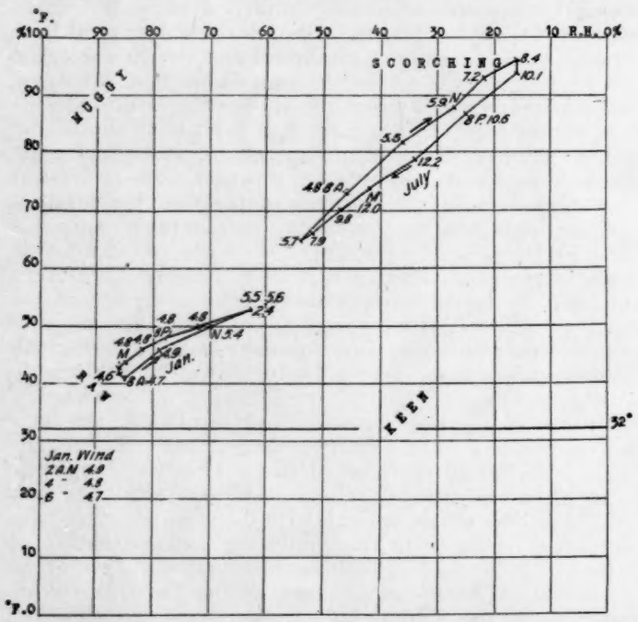

FIG. 2.—Bihourly averages of air temperature and relative humidity for January and July at Fresno, Calif. Figures near the hour marks show mean hourly wind velocity in miles and tenths.

the climate there, on inspection of the figures, could be summarized somewhat in this way:

(*a*) It is a climate of considerable extremes.

(*b*) An average midwinter day is chilly and damp in the early mornings (relative humidity around 85 to 90 per cent and temperatures 40° to 45°). The result in sensible temperatures is decided rawness. From 10 to 4, somewhat warmer and considerably drier (roughly 10° increase in temperature, with relative humidities around 60 per cent). The esult is pleasant sensible temperatures, sparkling, moderate weather during the middle of the day—decidedly agreeable. Chill and damp again become noticeable in the late afternoon, and nocturnal radiation further intensifies these conditions.

(*c*) An average midsummer day has excessively high temperatures, highest around 3 and 4, and very low relative humidity. For a short time at night only are conditions moderate. Temperature ranges are very great—twice as great as in winter. The long narrow form of the climograph shoots off into the "scorching" corner.

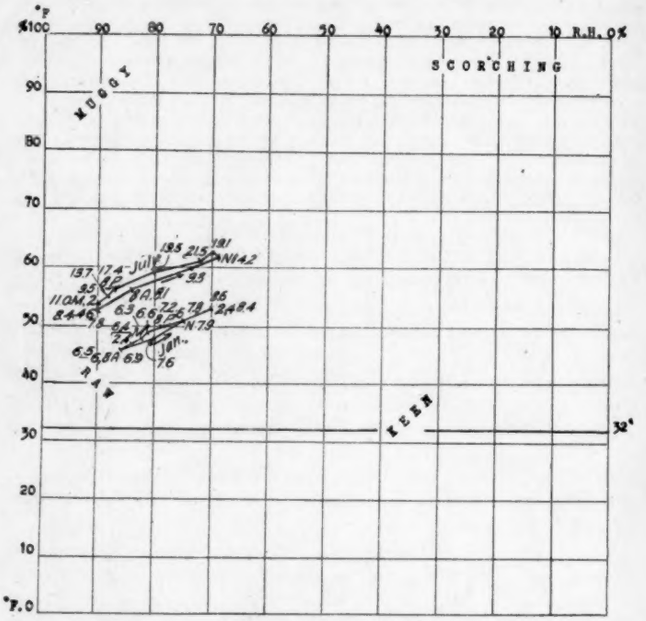

FIG. 3.—Bihourly averages of air temperature and relative humidity for January and July at San Francisco, Calif. Figures near the hour marks show mean hourly wind velocity in miles and tenths.

Its mere position and shape are as good as a page of description.

(*d*) From Fresno's coldest and dampest to its hottest and driest is a range of some 55° of temperature and 70 per cent of relative humidity.

Figure 3 compares the average day for January and July at San Francisco. The relative shapes and positions of these figures, together with those in figure 2, point the comparisons with great clearness. There is windward coast equability and continental variation in sharp contrast. There is the damp coolness of San Francisco's fog-bound summer against the Saharan heat of Fresno's, the bracing air of San Francisco's winter middays against the spring-like quality of Fresno's. Many other points are at once apparent.

Figure 4 shows the possibilities of tracing through the year the variations for any given part of the day. Again the long narrow figure indicates steady and fairly rapid progression from one extreme to the other, in one case from the raw, damp atmosphere of the winter mornings to the delightful early forenoons of midsummer; in the

other from the spring-like afternoons of winter to the desert heat of the summer afternoons.

A criticism of all climographs should be emphasized here, namely, that they can not show graphically the very important item of wind velocity as a determinant of human sensation in connection with temperature and relative humidity. The makeshift here adopted of placing alongisde of the month or hour points the average

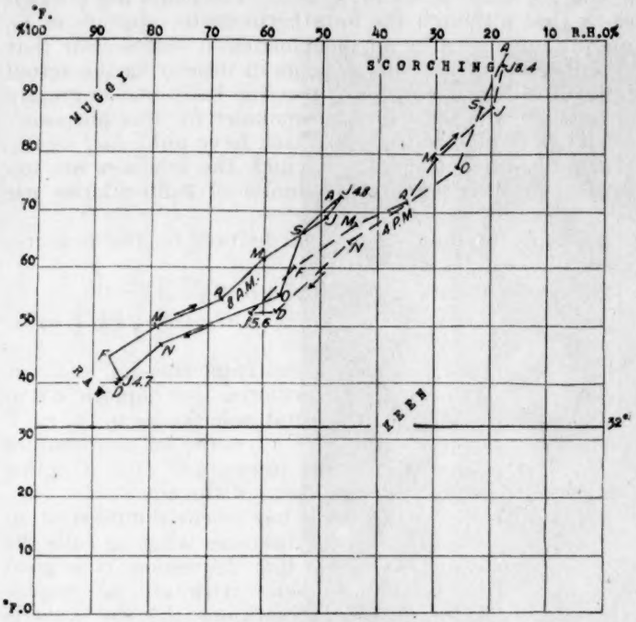

FIG. 4.—Monthly averages of air temperature and relative humidity at 8 a. m. and 4 p. m., Fresno, Calif. 8 a. m.=solid line, 4 p. m.=broken line. Mean wind velocities for January and July near initial letters of those months.

wind velocity is obviously unsatisfactory, but still a help to the fuller interpretation of the graphs.

Finally, figure 5 is presented to show the versatility of the climograph in illustrating the effects of non-periodic weather changes. The example is that of an interruption of the smooth summer coolness at Berkeley, Calif., on the coast, by the passage of the center of a pronounced high pressure north of the station. Daily maxima of temperature and minima of relative humidity indicate the progress of the change from the 19th of the month through the 30th, and letters show the prevailing wind direction for the corresponding days.

From positions in the "moderate" area of the figure, the succession of points suddenly trends out into the "scorching" area, showing at a glance what would otherwise need two curves and considerable description to make clear.

The climograph can be used in visualizing the effect of other cyclonic weather changes, such, for instance, as

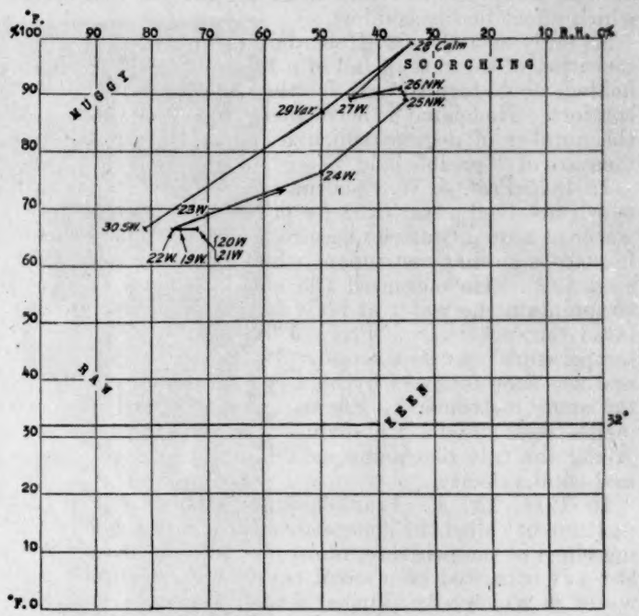

FIG. 5.—Effect of a hot wave on daily maxima of air temperature and minima of relative humidity at Berkeley, Calif., Sept. 19 to 30, inclusive, 1917. Figures=dates, letters=prevailing wind direction on the given date.

occur at the passage of the wind-shift line. With it one's conception of the effects of thunderstorms, sea breezes, Texas northers, and many more of the important characteristics of local climate and weather can be made more vivid. With it the climatologist can illuminate somewhat more brightly the endless columns of data which too often are dark and uninteresting to the "average man." And, like the curve, the climograph can be used with moderation.

THE KATATHERMOMETER: AN INSTRUMENT TO MEASURE BODILY COMFORT.

By ROBERT A. JACOB.

[U. S. Naval Proving Ground, Dahlgren, Va., June 30, 1920.]

It has long been known that dry-bulb readings do not furnish a definite index of bodily comfort. The human body is a dynamic organism, maintaining, under normal health, a nearly constant temperature in the close neighborhood of 98.6° F. This standard condition is controlled physiologically by the heat gained in the internal combustion of food and by regulation of the amount of heat lost from the skin and respiratory membranes. Since the air temperature is generally far below 98.6° F., it is seen that the body may be thought of as a mass of hot matter constantly losing heat, which loss is perpetually being made good by physiological changes which very nearly maintain the uniform thermal standard referred to above. When the rate of loss remains greater than the rate of gain for any considerable period we say we are cold; when the rate of gain becomes and remains greater than the rate of loss we say we are hot.

In either case we are uncomfortable and a regulation of one or both is necessary to reinstate a condition of comfort. To all intents the rate of heat gain is beyond our control and so our efforts to remain comfortable have to do with a regulation of the rate of heat loss from the body. Obviously we are interested in this discussion in the measurement of the effect of the atmospheric condition on the body.

The methods we have at present for measuring the departure of our atmospheric environment from that standard which produces the greatest comfort are wholly inadequate. Measurements of dry temperature and relative humidity by means of the wet-bulb thermometer do not give a true idea of the condition. The dry thermometer is a static instrument and averages the influences of the environment, while the body, as has been said above, is a dynamic organism maintaining by its

own physiological activities a constant temperature. As for instruments to measure relative humidity, it is sufficient to say that these instruments do not indicate the conditions they are designed to measure as accurately as they should. Together with temperature and relative humidity, bodily comfort is also affected by air movement, or, reducing the whole matter, we may say that the loss of heat from the body to the atmosphere in general and air movements which remove the saturated and heated air and supply cooler and drier air are the conditions which affect bodily comfort.

As early as 1826, Dr. Heberden (1) suggested that observation of the rate of fall of a thermometer, previously heated, would furnish data for the computation of bodily comfort. He heated a thermometer to 100° F. and noted the number of degrees which it fell in 10 minutes as a measure of "sensible cold."

In 1875 Prof. J. W. Osborne introduced an apparatus which involved a wet cylinder of paper containing warm water as a quantitative measure. Mr. A. Piche, brought forward a similar instrument which he called a *deperditometer* (2). He measured the amount of gas necessary to maintain the water at body heat, the gas being regulated automatically. Prof. J. R. Milne's "constant temperature" *psuchrainometer* (3) was introduced in 1911 and was soon followed by his "constant energy" type of the same instrument. Electrical heating and measurements were used. He deduced an empirical formula giving the rate of cooling as a function of temperature and wind velocity.

In 1911, Dr. F. Frankenhäuser (4) introduced an instrument called the *homœotherm* for measuring the cooling effect of temperature, moisture, wind, solar radiation, etc. It consisted of a small copper cylinder filled with water in which was plunged a thermometer. It was so designed that a fall of one degree centigrade corresponded to the loss of one gram calorie. Various thicknesses of different textiles were wrapped around the cylinder to approximate more closely the environment of the body. It was noted that an increase in wind velocity had a more marked effect than a sharp fall in temperature.

Prof. Leonard Hill introduced two instruments; one, the *caleometer* devised in collaboration with Prof. O. W. Griffith, consists of a small electrical furnace automatically kept at body temperature and working on much the same principle as instruments of the same class already mentioned. The other invention is the *katathermometer* (5) and was first described by the inventor in 1913.

The katathermometer outfit consists of two specially constructed thermometers with large bulbs and stems graduated from 86° to 110° F., one to be used as a dry and the other as a wet bulb thermometer. The bulbs are heated by means of hot water to a temperature of about 110° and place in clips which hold them in a horizontal position, after drying the one and removing the excess moisture from the other. The time taken for each thermometer to fall from 100° to 90° F. is observed by means of a stop watch and these readings serve as values to be transformed into an index representing the cooling effect of the air immediately surrounding the body.

On an ideal spring day the wet has been found to take 45 seconds and the dry 2 minutes 20 seconds. Under any conditions the maximum time for the wet sould be 1 minute and the dry 3 minutes. Factors have been determined for each thermometer so that the rate of cooling can be expressed in milli-calories per square centimeter per second. The rate of fall of both thermometers will be affected by air movement and radiant heat as well as by air temperature, and the wet bulb will also be affected by the humidity. An extended series of experiments was made by Prof. C.-E. A. Winslow (6) of the Yale Medical School, using this apparatus.

Three series of experiments were made under varying conditions, the results in each case being compared with the vote of from three to twenty observers, who expressed their opinion on an arbitrary scale as follows: 1, cold; 2, cool; 3, ideal; 4, warm; 5, hot. The deductions drawn show that although the katathermometer appears to be unduly influenced by air movement, "it seems clear that this instrument is of great value in measuring the actual influence of air conditions upon the body and is greatly superior to the ordinary thermometer for this purpose."

Messrs. Hill, Griffith, and Flack have published an important contribution (7) in which the readings are expressed in the fundamental units of milli-calories per square centimeter.

Empirical formulas have been deduced for the measurement of heat loss as follows:

For the dry kata— $H=(0.27+0.49\sqrt{V})(T-t)$.

For the wet kata— $H'=(0.27+0.49\sqrt{V})(T-t)+(0.085+0.102V^{0.3})\ (F-f)^{4/3}$

where H, H' are the heat losses from the dry and wet katas, respectively, in milli-calories per square centimeter per second, V is the wind velocity in m. p. s., T is the katatemperature (36.5° C.), t is the air temperature (° C.), F the saturation vapor pressure at 36.5° C. (45.4 mm.), and f is the vapor pressure of the air.

Mr. C. W. B. Normand (8) has recently published an extensive article in which he discusses what he calls the "upper climatic limit." In this discussion is a good account of the katathermometer with several graphs. He finds that for ordinary conditions the wet kata is very suitable but, under those conditions of temperature, air movement and humidity which tend to make life cease, he finds that a large-bulbed wet thermometer is more desirable.

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THE SCIENCE OF VENTILATION AND OPEN-AIR TREATMENT.

By Dr. LEONARD HILL.[1]

The British Medical Research Council has just issued, under the title of "The Science of Ventilation and Open Air Treatment," a very commendable study upon the important relations between atmospheric conditions, health and comfort. The work of Dr. Leonard Hill on

[1] The Italian Government has conferred upon Dr. Leonard Hill, F. R. S., the Italian silver medal "Al Benemeriti della Salute Publica." (Science, New York, Oct. 15, 1920, p. 358.)

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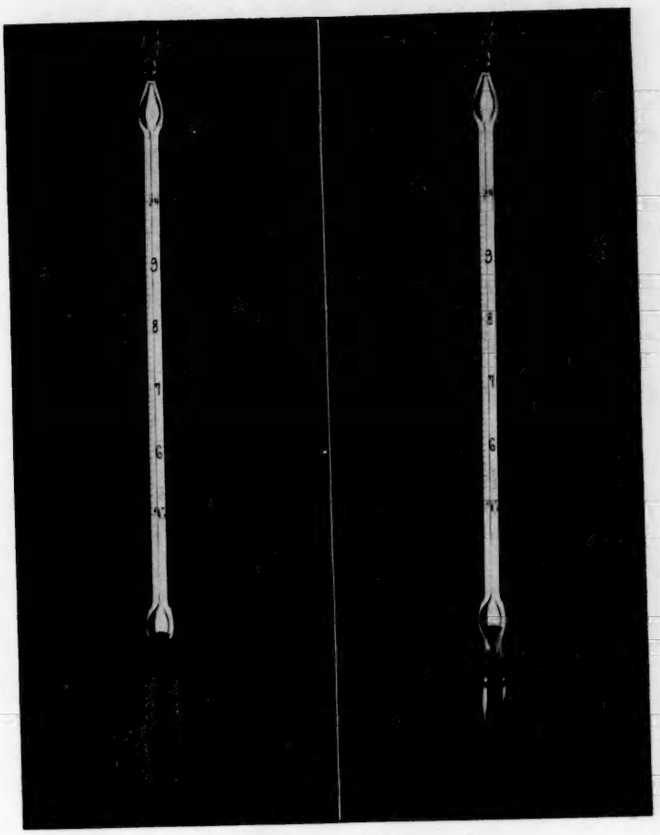

FIG. 1.—Wet and dry katathermometer.

some of the uses of the katathermometer have been discussed before.[2] There is such a great mass of material presented in the two volumes, which constitute the two parts of the work, that it affords a very prolific source of information for those who are interested in this subject.

Some of the chapter headings from the two parts will serve to indicate in a general way the nature of the material and the discussion. In Part I we find: The cooling power of the atmosphere and its measurement by the katathermometer; the conductivity of the skin and heat-loss in relation to surface and deep temperature; the influence of the atmospheric environment on the respiratory membrane; records of observations in numerous places under varied conditions such as cool, sunny, and close days in Egypt, army huts, tents, school rooms, playgrounds, etc.

Part II deals with the chemical purity of the air, radiant energy, sunlight and pigment, heat-stroke, clothes, ventilation and heating of dwellings and work rooms, housing, sickness, and mortality, and open-air treatment.—*C. L. M.*

[2] Atmospheric Conditions which Affect Health, *Quar. Jour. Royal Meteorological Soc.*, July, 1919, pp. 189–207. Abstract reprinted from *Science Abstracts* in Mo. Weather Rev., Nov. 1919, p. 810. Also review by Ellsworth Huntington in *The Geographical Review*, April-June, 1920, pp. 362–363.

CLIMATE AND ITS RELATION TO ACUTE RESPIRATORY CONDITIONS.

By Lt. Col. ESTES NICHOLS, M. D.

[Excerpts from paper read at the meeting of the American Climatological and Clinical Association, at Atlantic City, N. J., June 17, 1920.]

Following the last three years, 1917–18–19, during which time we have experienced a remarkable prevalence of acute respiratory diseases not previously met and studied to such an extent by this generation of observers and in reviewing many reports from all parts of the world, we frequently note reference as to the causation of epidemic bronchitis, influenza and pneumonia and their relation to certain meteorological conditions which, if not held responsible for them, are indicated as having a great influence upon the spread or the sudden termination of these diseases. As these references are made by the most serious writers, it seems necessary for us as climatologists to study carefully every meteorological condition that may have any bearing on such a formidable disease as influenza and pneumonia.

What were the unusual weather conditions, if any, prevailing to account for this most serious bacterial attack upon the human race? For instance, a medical writer in Spain states: "After the subsidence of the epidemic of influenza in Spain last spring, the summer was extremely dry, the drouth being worse than even the oldest inhabitants could remember, and the epidemic flared up again in a much severer form, and the disease, which first seemed to yield to the extreme hot weather, suddenly spread throughout the whole of Spain."

Another writer, from the Philippines, states that "The disease ravaged in the islands for about six weeks, when a typhoon with torrential rain followed by strong winds swept away the last vestige of the disease."

Baccarini is inclined to believe that the germs causing it had their virulence suddenly enhanced by some mysterious influence, electric, atmospheric, or telluric. Another writer states "The epidemic appeared after a very hot season had suddenly been succeeded by a very cold one and that perhaps the weather precipitated a large amount of other respiratory infections such as always become prevalent at this season (autumn)." This is answered by many other writers who state that this pandemic differs from that of 1890 and 1892 in that acute nasal catarrh and sinus involvement were conspicuous by their absence this year. It is also said that among the causes which contributed to the high incidence of influenza-pneumonia in the American Expeditionary Forces were working and sleeping in wet clothes and shoes, eating of food served cold, insufficient blankets for warm sleeping during the wet, cold period in northern France, yet several exhaustive reports of the incidence of influenza-pneumonia among troops stationed in barracks and tents in this country show that the weather conditions when the epidemic struck were unsurpassed; no rain, not cloudy, fair and warm—the weather being all that one could wish for the troops occupying tents, and that a long period of fine weather followed the onset of the pandemic. In letters sent out by a medical association for the prevention of disease, a slip was inclosed which reads: "Spanish influenza is undoubtedly due to lack of sunshine and fresh air, to dampness out doors and in, and to getting wet feet." This is not quite as amusing as a special telegram to one of the leading Philadelphia papers dated Boston, October 7, which reads thus:

"In connection with the influenza epidemic the directors of the 'Mother' Christian Science Church here announce that the mind is a source of contagion and that elements can contaminate only as diseased images held before the thought and paraded before an excited imagination preliminary to having them expressed on the body through fear and apprehension." Another writer states "The numerous gases used on the battle fields of Europe with their highly poisonous properties, the liberation of large quantities of ground air high in carbon dioxide content due to trench digging and shell holes, the gases from decomposing bodies of men and lower animals, and those set free by the destruction of cities and munition dumps during the last four years may have combined to form a gaseous compound with highly toxic properties probably due to rearrangement of molecules by the termendous concussion produced by high explosives." With this idea in mind he states, "I am going to advance the theory that the condition termed influenza is in reality a nonbacterial, noncontagious disease caused by the inhalation of small amounts of depressing, highly irritating, high density gas present in the atmosphere, especially at night when the air is surcharged with moisture, more particularly near the surface of the earth." He also states, "The mode of transmission is undoubtedly through the agency of the atmosphere."

The idea that some atmospheric influence or free-from-germ explanation of infections and epidemics was promulgated by Wagner many years ago in his work on pathology under the title of "The Epidemic Constitution of Disease."

Dr. Onodera, of the Society of Internal Medicine of Japan, has laid stress on the meteorologic relation of the occurrence of influenza epidemics, the latter running parallel with the severe cold that returns at about 30-year intervals. There may possibly be some relation of extreme cold periods and crowding.

MONTHLY MEAN TEMPERATURE.

	1890	1891	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918
September	62.9	66.4	65.5	62.8	64.5	64.2	64.1	62.6	64.4	68.1	64.2	61.1	61.0
October	51.3	50.7	56.2	51.5	55.8	53.2	56.7	57.7	57.1	55.5	55.3	50.7	56.0
November	41.7	40.9	42.9	46.1	40.7	40.8	44.8	45.4	42.5	44.6	43.2	39.4	44.4

TOTAL MONTHLY PRECIPITATION.

September	5.38	3.96	0.88	3.93	1.83	2.33	2.32	2.52	0.17	1.35	2.54	2.23	6.16
October	7.63	4.62	1.58	1.76	1.15	7.44	1.22	10.64	3.81	3.30	2.05	4.68	1.20
November	0.67	2.21	0.83	1.51	4.56	6.40	3.37	2.74	3.28	1.90	2.54	1.08	3.37

MONTHLY MEAN SUNSHINE.

September	52	71	62	57	60	62	50	62	80	70	73	70	59
October	42	58	60	66	68	54	63	39	55	56	72	57	55
November	65	52	48	49	53	54	57	49	57	52	63	68	53

MONTHLY MEAN WIND VELOCITY.

September	5.5	6.3	7.3	8.9	7.6	8.9	7.5	8.0	8.1	8.4	9.1	7.8	8.7
October	6.8	8.7	8.7	8.6	9.8	9.0	8.1	8.8	7.9	8.8	9.5	10.4	8.2
November	7.2	9.7	8.8	10.5	9.9	10.0	9.7	8.8	10.5	9.6	8.8	9.3	8.9

MONTHLY MEAN PREVAILING WIND DIRECTION.

September	nw.	sw.	n.	n.	n	n.	n.	n.	n.	nw.	s.	n.	n.
October	ne.	n.	n.	w.	nw.	n.	n.	n.	s.	s.	n.	n.	s.
November	nw.	n.	n.	w.	nw.	w.	sw.	n.	n.	sw.	sw.	nw.	ne.

MONTHLY MEAN CLOUDINESS.

September	4.8	2.9	4.0	4.9	4.7	4.6	6.0	5.3	3.3	4.2	3.7	4.7	5.1
October	5.8	4.2	4.3	4.0	4.1	5.3	4.7	6.7	5.2	5.1	3.8	5.2	5.1
November	3.5	4.8	5.3	5.7	5.4	5.4	5.2	5.8	4.8	5.2	4.3	3.8	5.1

MONTHLY MEAN HUMIDITY.

September	85.3	81.6	73.0	76.8	77.2	74.8	77.6	76.0	65.8	77.6	73.4	70.0	75.6
October	80.4	77.7	73.0	76.8	68.2	75.0	71.4	77.8	72.0	83.4	75.4	74.4	76.6
November	76.0	74.0	71.8	68.3	71.0	67.8	68.4	68.3	65.0	68.1	76.4	61.0	70.2

To get an idea of what happened during the nine weeks' period from September 2 to November 9, in a meteorological study we have made a chart (omitted) of the mean daily temperature for September, October, and November, 1918, and also for these months for the last 10 years, and have compared them with the same months for the years 1890–91. We also have made a daily chart covering the same period for precipitation, humidity, sunshine, cloudiness, wind velocity, and wind direction. As a rule the epidemic began and reached its height in the eastern portion of the country in the same manner as it did in 1890.

A New England weather station was taken for observations because, like the epidemic in 1890, it commenced in New England and spread westward in a fan-shaped manner. As will be noted by the chart, the precipitation for the first 18 days of September was nearly 5 inches. This is a very unusual rainfall. In September of 1890 it is noted that the precipitation was also over 5 inches. The only bearing it has on acute respiratory conditions is the tendency to drive people inside and to cause crowding. So far as the other meteorologic observations are concerned, there is nothing unusual as in comparison with the period of the last 10 years.

The time it took to exhaust the susceptible material was not more than eight weeks in any one place. The death rate was highest in manufacturing and lowest in strictly rural communities. All towns untouched by railroads showed a very low death rate. Conditions of housing and crowding which increased indoor contact, no matter where found, increased the death rate. The comparison of these rates with the proportion of foreign and native born shows that in the communities having the highest and lowest percentage of native born the death rate rises or falls accordingly, as a high percentage of American born means less crowding and better sanitary conditions generally.

The study of the Student Army Training Corps and students wherever located shows that as living conditions approach those in the Army so does the death rate approach that of the Army, i. e., when a large number of persons live, sleep, and eat together in a large barrack room the death rate is almost invariably higher. This is true no matter where people are housed in this manner, whether in Army camps, miners in South Africa, or the congested sections of our cities with their apartments, flats, and tenements. It is noteworthy that in many of our large western and southern cantonments the morbidity and mortality was as high or higher than in many of our eastern camps, so that climatic influence does not explain the difference nor does it explain the difference in morbidity of influenza in cantonments of 15.9 per cent being complicated with pneumonia in barrack camps against 9 per cent in tent camps where the men were quartered in small groups of five or six men to a tent against 50 to 150 in a barracks building.

This has also proven quite true of institutions and industrial plants where the same sort of housing has occurred. Already we have been impressed with the heavy sacrifice in human lives demanded for the privilege and necessity of assembling large numbers of men in barracks for military, industrial, and educational purposes.

What relation was there between bronchitis and climate? The weather may have encouraged it, but while there was a good deal of cloudiness and perhaps unusually cold weather in the fall and winter of 1917, yet there was no unusual humidity or precipitation—only the snowfall was greater.

I think we must admit, however, that climate, so far as seasons go, does play a great part in the incidence of acute respiratory diseases, especially pneumonia. We must look further than climate, however, for the explanation of these diseases during the winter of 1917. I have always believed that no climate can rise above the conditions of housing. The quartering of troops in unaccustomed climates will not explain it, but the housing of a large number of men together in one room with the change from overheated homes to the more or less cold barracks system of many of our camps, will account for much of it, but this condition was not confined to our Army camps. Acute respiratory conditions were on the rampage during the winter of 1917 among the civilian population, and I believe the foundation for the pandemic of the autumn of 1918 was then laid.

The following statement may surprise you all, but I believe that the fuel administration had the most to do with the causes which led up to the titanic struggle between bacterial and human life. Not that they were to blame. It was a military necessity. And, my friends, it is impossible for us to play at this war game without paying for it in both the front line and the extreme rear line or the homes that were necessarily mobilized for war purposes.

During the winter of 1917, on account of fuel shortage many people were obliged to close a large part of their houses and to live in a few rooms. This was especially true of the poor. Apartment houses were crowded and poorly heated. The people who could afford it flocked to hotels, many of which were under heated and overcrowded. People crowded together as never before witnessed in the civil population of all countries. Windows and doors had to be kept closed to keep the cold out, which resulted in a concentration of bacteria laden, indoor air, due to coughing and sneezing. The acute respiratory conditions in 1917, I feel, had some very definite relation to those in 1918. As the warm weather approached in the summer of 1918, these conditions subsided because windows were opened and people had reopened their closed rooms; the concentration of germ laden air had become diluted and it almost appears that a certain concentration is necessary for the spread of some of these diseases.

I have failed thus far to show any meteorological factor that influenced the pandemic with the exception of change in seasons. Does climate have any effect on the bacterial flora in any sense as it does on our terrestrial flora? This is a question that will bear some investigation.

* * * I feel that climate will have little to do with the next outbreak but it will come, perhaps not in my time and perhaps not for a longer period of time, but you climatologists who are present when a new susceptible population is established need not study meteorological influences or protections against it except so far as it concerns seasons. I do earnestly urge you to study housing, ventilation and sanitation and to be ever on the watch for business depressions, social problems such as widespread strikes, and new wars, which for economic reasons will cause people to live under restricted and crowded conditions.

THE CONTROL OF PNEUMONIA AND INFLUENZA BY THE WEATHER.

By ELLSWORTH HUNTINGTON, Research Associate in Geography, Yale University.

[Review and discussion by J. B. Kincer, Meteorologist, U. S. Weather Bureau.]

In the January, 1920, issue of *Ecology*, the official publication of the Ecological Society of America, Prof. Ellsworth Huntington gives in considerable detail the results of an investigation made by him as to the relation of temperature and relative humidity to the number of deaths from pneumonia in New York City for the period from April, 1917 to March, 1918.

He points out that in former investigations of this character the monthly figures of deaths have been compared with the weather conditions of the particular month, and these have indicated that deaths from pneumonia have a direct relation to outside temperature and decrease systematically as the temperature rises.

In order to test the matter in another way, Prof. Huntington has taken the day instead of the month as a unit and has tabulated the deaths from lobar and broncho-pneumonia in conjunction with the outside temperature for the particular day on which death occurred. For this purpose he has made 8 divisions of temperature for the period, namely, 20° or less, 21°–32°, 33°–45°, 46°–55°, 56°–65°, 66°–70°, 71°–75°, and over 75° F.

TABLE 1.—*Average daily deaths from pneumonia at various mean temperatures in New York City, from April, 1917, to March, 1918.*

Mean temperature, °F.	20° or less.	21°–32°	33°–45°	46°–55°	56°–65°	66°–70°	71°–75°	Over 75°.
Lobar-pneumonia...	26.5	26.4	27.8	20.6	17.4	9.4	6.3	6.7
Broncho-pneumonia.	8.3	9.6	8.2	6.2	5.4	3.9	2.5	3.3
Number of days.....	30	47	72	70	51	31	38	26

Table 1 shows the number of deaths reported under each of these groups of temperature. This table indicates a decline in the death rate with rising temperature. His comment on the table is as follows: "At the lowest temperatures there is a little irregularity, due to the fact that a mild epidemic doubled the death rate for a couple of weeks at the end of March. In view of the lateness of the season at which this occurred, it is surprising that the death rate at temperatures of 33° to 45° has not been raised much higher. In ordinary years the relation between low temperature and the death rate would be even stronger than appears in Table 1. At the right-hand end of the table a slight increase in deaths is apparent at high temperatures, above 75°. Judging by more abundant statistics for other diseases, this is a constant characteristic, and means that high temperatures as well as low are bad for pneumonia."

As a test of Shaw's [1] conclusion that influenza as well as pneumonia varies inversely with the temperature, Prof. Huntington has used the weekly figures for deaths from influenza in New York City during the 30 years from 1889 to 1918 and presents these data by means of a graph. He points out that deaths begin toward the end of September or at about the time when the nights first become frosty; the death rate suddenly increases about the middle of December, at approximately the time when the mean temperature falls below freezing, and reaches a maximum a little after the middle of January, or the time of minimum temperature.

[1] Napier Shaw, *Quar. Jour. Roy. Met. Soc.*, Vol. XLV, July, 1919.

RELATION OF HUMIDITY TO PNEUMONIA AND INFLUENZA.

Prof. Huntington takes up also the question of the relation of relative humidity to deaths from pneumonia and influenza during the period for which data are given for temperature. He uses the same method in this case as in the other, that is, by comparing the number of deaths on a given day with the outdoor humidity conditions on that particular day, and the result is given in tabular form (table not reproduced here). The days have been divided into 8 groups, according to temperature, as in the other case, and each group has been subdivided into 2 divisions: (1) Days with low relative humidity, (2) days with high relative humidity. In each of the 8 temperature groups the days with high relative humidity have an advantage over the drier days, ranging from 0.8 per cent up to 26.8 per cent. He discusses in considerable detail the significance of the statistics presented and comments thereon as follows:

During the winter the air in the average house in New York has a relative humidity of only about 30 per cent, while the deaths from lobar pneumonia number about 27 or 28 per day for the year under discussion. Suppose, now, that during the warm weather, when the outside air averages 55° to 70°, the humidity were to be as low as in our winter houses, apparently the pneumonia death rate would increase by at least a third, and perhaps one-half, over what it is in such weather when the humidity is 70 per cent or more. Of course a far larger body of figures is needed before we can determine the exact effect of any given condition, but the principle seems clear. Apparently we are killing people by the thousand simply because we do not properly humidify the air in our hospitals.[2]

TABLE 2.—*Effect of variability of the weather upon deaths from lobar and broncho pneumonia in New York City from April, 1917, to March, 1918.*

	April–September.			October–March.		
	Number of days.	Change in deaths from pneumonia.		Number of days.	Change in deaths from pneumonia.	
		Lobar.	Broncho.		Lobar.	Broncho.
Rise of 6° or more	15	−1.60	−1.00	43	−0.40	0.26
Rise of 2–5°	54	0.61	−0.21	44	1.07	0.64
Change of 1° or less	50	0.04	0.34	25	1.32	0.80
Drop of 2–5°	43	0.28	0.26	28	1.07	−0.89
Drop of 6° or more	20	−1.55	−1.30	42	−1.64	−1.21

NOTE.—The figures in the body of the table indicate the average amount by which the number of deaths increased or decreased *on the days* having the indicated changes in mean temperature. The change in mean temperature is the amount by which the average temperature for a given 24 hours is above or below that of the preceding 24 hours.

Prof. Huntington discusses also the relation of variability of temperature to deaths from pneumonia, by making comparisons on the same basis as in the other two cases. He presents Table 2 showing the relation of temperature rises of certain magnitudes and falls of similar amounts to the number of deaths from pneumonia for the same period as in the other cases. He bases the following comments on this table:

During variable weather, even when patients are in well-warmed houses, a drop in temperature stimulates by causing a decrease of the unfavorably high temperature which regularly prevails in our houses. It also causes much more movement of the air than at times when the weather stays stationary from day to day. The harm that comes from a rise in temperature at any season, except summer, is not easy to explain. Apparently it arises largely from the fact that when the outside air grows warm the inside is apt to run up to high levels, even 75° or more, a condition which is decidedly harmful. If this is the case, however, the benefit that apparently comes to pneumonia patients from a rise in temperature is puzzling. Possibly during the year used in this article the increased humidity, which usually prevails when the temperature rises, overcame the bad effect of increased warmth.

The epidemic of influenza in 1918 is finally discussed and some apparent relation to weather conditions is shown, but at the same time it is pointed out that nothing seems better established than that epidemics of this character may break out at any season and that, once started, they run their course in spite of weather or climate. The only question therefore in this connection is how far the conditions of the air may increase or decrease their severity.

DISCUSSION.

There is perhaps no subject which appeals to mankind more insistently than that of health, life, and death. Gladly one sacrifices the material accumulation of years of toil to forestall, or even postpone for a short season, the call of the "Grim reaper." In view of this, there is naturally a keen interest in any investigation of the character above outlined, especially so in a country such as ours, where opportunity affords for one to select for his place of abode almost any desired character of climate. The numerous inquiries received by the Weather Bureau, desiring information as to climatic conditions in different sections of the country, from people in every walk of life, seeking the return of lost health and prolonged life, attest the general interest in the subject and the universal belief that certain atmospheric conditions, even if not so efficacious as the fabled "Fountain of Youth," are potent to restore health and vigor.

At one place may be found a uniformly mild and humid climate, such as prevails at San Francisco, for example, and at another weather characterized by wide temperature variations, with rigorous winters, as in the north-central sections of the country, or even a semidesert environment, as in our great Southwest. As a matter of contrast in the way of temperature it may be pointed out that in San Francisco the average January temperature is 50° and the average July temperature only 57°, while in some north-central States the means are about zero and nearly 70°, respectively; in some southwestern sections of the country the average July temperature is above 90°. In much of the West, humidity conditions during the warmer portion of the year closely approach those obtaining in our artificially heated houses during cold weather.

The statistics presented by Prof. Huntington in this study are interesting, and, on their face, apparently verify, to some extent at least, the conclusions he draws therefrom; that is, that the number of deaths from pneumonia *on a given day* has a more or less direct relation to the temperature and humidity conditions prevailing *on that particular day*. It appears, however, that this method of applying the weather statistics to the mortality rate is open to serious question from more than one standpoint. This is particularly true with respect to the refinement with which he has grouped the days with certain outside temperatures for comparison with unknown conditions prevailing indoors. The same is true in the case of the relative humidity data. We shall show presently that, so far as the records at hand indicate, there is no dependable relation between outdoor temperature and relative humidity and that usually prevailing within

[2] If this holds good generally, there should be a marked contrast in the death rate between those sections of the country having humid climates and those characterized by the dryness of the atmosphere, the comparison being to the disadvantage of the drier climates, notwithstanding they are usually considered as healthful, or more so, than the more humid localities. For example, the average relative humidity at San Francisco for July, 1920, based on observations taken at 5 a. m., noon, and 5 p. m., local mean time, was 83 per cent, compared with an average at Denver of 41 per cent.—J. B. K.

our artificially heated houses, particularly in the colder weather.

Furthermore, the actual number of deaths from pneumonia, as well as from most other diseases, on a given day, must necessarily have a more or less definite relation to the prevalence of the disease and its virulence, and these obviously must depend on conditions, weather or otherwise, during several days preceding that on which death occurred, and could have no possible relation to weather conditions at the time of death. It goes without saying that if one does not contract pneumonia he will not die from it, and, in most cases of demise, the disease is contracted several days before death. Isn't here, then, the fountain head, or critical period, instead of the day when death occurs? Isn't the question of life or death in many cases decided for the individual prior to the day of demise?

It is the experience of many people that a sudden and marked change in temperature in winter, especially from cold to warm, results in what is commonly termed "a bad cold," which appears to be a distant relative of pneumonia. In the natural sequence of our winter weather a cold period is followed by a warm in about the average time required for pneumonia to reach the critical stage. If the disease were contracted during a sudden change from cold to warm, say, and death should occur during the following cold period, is it not possible that by Prof. Huntington's method we might erroneously charge the death to cold weather, and vice versa? We may cite, for example, the condition that prevailed in Washington on, and immediately succeeding, March 4, 1909, or at the time of the presidential inauguration of that year. Many persons, both Washingtonians and visitors, exposed themselves on the 4th to about as inclement weather as could be imagined; the result is a matter of history. In a week or 10 days thereafter an unusually large number of deaths from pneumonia occurred. The temperature averaged 32° on the 4th, and the streets ran full of slush composed of snow and water, with a high biting wind blowing at the rate of 25 to 30 miles an hour. Six days thereafter, however, or at about the time the large death rate began to occur, the temperature had risen to an average of 60°, and did not go below 40° until the 15th. We may ask, are those deaths properly chargeable to the weather prevailing on the day when death occurred or to the conditions on the 4th?

When statistics tell us that deaths from pneumonia are more frequent when the temperature is low, considering the year as a whole, it is equivalent to saying that they are more frequent in the winter season, but does this necessarily mean that low temperature is the cause? If so, we should have a progressive decrease in deaths from northern to southern limits of the country, with the greatest number in the north-central border States. On an average the temperature falls below 32° each winter on 182 days at Bismarck, N. Dak., on 110 days at Chicago, Ill., and on 95 days in New York City. On the other hand, freezing weather is experienced on the average on 5 days only in Jacksonville and New Orleans and on less than 1 day in San Francisco. As no such wide variations in the death rate have been shown to exist in these localities, may it not be that other features of weather, which have smaller geographic variations, play an important part in the matter? Temperature variability, or the change in the mean temperature from day to day, is usually about twice as great in winter as in summer; variations in barometric pressure have a similar seasonal range, and also the amount of sunshine; in New York the average number of hours of sunshine daily in January is 4.9 against 9.3 in July.

In discussing Table 2, Prof. Huntington says: "The harm that comes from a rise in temperature in any season except summer is not easy to explain. Apparently it arises largely from the fact that when the outside air grows warm the inside is apt to run up to high levels, even 75° or more, which is decidedly harmful." In this case we should expect to find the seasonal death rate reversed in northern and southern localities—Chicago and New Orleans, for example. The normal daily temperature is above 75° in New Orleans from the middle of May to the end of September, and does not go below 53° during the winter season. In Chicago, on the other hand, it does not reach 75° even in midsummer, but is below 40 from the middle of November to the end of March. The higher death rate in New Orleans, therefore, should come in the summer season.

Incidentally, Prof. Huntington speaks of a mild epidemic of pneumonia in New York as doubling the death rate for a couple of weeks the latter part of March, 1918, within the period covered by his investigations. An examination of the meteorological records for New York for that month discloses the fact that the month averaged 3.7° per day above the normal, and that only 3 days after the 16th had temperatures below normal, and they only slightly below. The last half of the month averaged 6.4° above the normal. While these temperatures, as March temperatures go in New York, should have favored a comparatively low death rate, as compared with this month in preceding years, he speaks of "a mild epidemic." However, with a further examination of the records for that month, an unusual condition appears as to temperature variability. On the 11th the mean daily temperature was 26° and on the following day it had risen to 40°; 32° was the average for the 15th, 48° for the 17th, and 56° for the 19th. In fact, for the month as a whole, only once in the preceding 20 years had the temperature been more variable in March. In contradiction to this, Table 2 shows a decline in death rate with large variability. May not this apparent discrepancy result from the method of considering the data for the day on which death occurred?

Is there a dependable relation between outdoor temperatures and relative humidity, and changes therein, to the indoor conditions in our artificially heated houses during the winter season? On this question hinges the practical application of the data Prof. Huntington presents in his paper, for those representing the meteorological side of the problem are all outside data. If there is no dependable relation, obviously the outside data tell us nothing, as the patients on the day of death were wholly under the influence of temperature and moisture conditions obtaining in the sick room.

No extensive simultaneous observations have been made in this country of temperature and humidity conditions indoors and out, although some data are available. Prof. Ward[3] made daily observations of this character from November 3 to November 23, 1899; 3 to 5 observations were taken daily. An examination of these data shows very little relation between the outdoor and indoor conditions. For example, we find for a given day an indoor relative humidity value of 32 per cent against an outside average of 60 per cent, and for another day an inside average of 31 per cent when the outside readings averaged 91 per cent. The range from minimum to maximum values was nearly three times as great outdoors as indoors. Moreover, on the days when the relative humidity inside was 30 to 32 per cent the outside averages were 60, 63, 64, 69, 70, 77, 90, and 91 per cent. Likewise in the case of temperature there was little comparability.

[3] See MONTHLY WEATHER REVIEW, Sept., 1908, 36:282.

On days with an indoor average of 67°, the outdoor averages ranged from 25° to 47°; with 68° indoors, the outdoor range was 24° to 39°; with 69°, 28° to 41°; and with 71°, 28° to 46°. It is further noted that the highest and the lowest mean daily outdoor values, 25° and 47°, occurred with an indoor mean of 67° on each day.

TABLE 3.—*Mean daily temperature and relative humidity indoors and outdoors at Topeka, Kans., November and December, 1909.*

Date.	Temperature.		Relative humidity.	
	Indoors.	Outdoors.	Indoors.	Outdoors.
Nov. 18	72	41	29	58
19	72	51	30	53
20	72	58	40	68
22	69	33	35	81
23	73	37	28	70
24	76	56	30	57
26	71	64	55	78
27	73	63	54	80
29	73	44	37	99
30	79	49	41	100
Dec. 1	75	50	39	81
2	71	43	34	75
3	70	41	37	91
4	71	24	26	94
13	76	25	22	87
14	76	27	23	75
15	75	25	20	76
16	74	34	23	74
17	71	10	20	63
18	74	12	17	75
20	72	15	20	73
21	72	19	19	74
22	71	17	20	92
23	75	24	19	87
27	75	25	23	73
28	77	21	18	81
29	74	4	15	72
30	74	30	19	68
31	76	34	22	78
Means	73	34	28	77

TABLE 4.—*Comparison of indoor and outdoor temperatures at Topeka, Kans., November and December, 1909.*

Indoors.	Outdoors.
64	32.
66	52, 58.
67	41.
68	7.
69	6, 14, 26, 38, 41.
70	11, 42, 43, 44.
71	11, 22, 27, 31, 38, 59.
72	23, 24, 26, 37, 43, 46, 47, 48, 52, 53, 54, 62, 64, 67.
73	5, 12, 16, 18, 18, 19, 22, 24, 26, 37, 37, 40, 45, 50, 61, 68.
74	−1, 13, 19, 26, 29, 31, 33, 36, 41, 49, 50, 65, 66.
75	6, 23, 29, 30, 39.
76	8, 20, 20, 25, 31, 32, 44, 52, 59, 65.
77	17, 17, 18, 25, 28.
78	17, 25, 41.
79	23.
80	32.
82	46.

NOTE.—This table shows the variations of outdoor temperatures with those observed indoors as shown in first column.

TABLE 5.—*Comparison of indoor and outdoor temperatures by grouping certain values of outdoor readings.*

Outdoor.	20° or less (22).	21–32° (25).	33–45° (19).	46–55° (12).	56–65° (8).	66–70° (3).
	°	°	°	°	°	°
Outdoor averages	13	27	40	50	62	67
Indoor averages	74	74	72	73	72	76

NOTE.—The groupings of outside temperatures in this table correspond to the divisions shown in Table 1 of Prof. Huntington's data. (Figures in parenthesis show number of observations.)

A somewhat more extensive series of observations was made by Mr. S. D. Flora,[4] in charge of the Kansas Climatological Service of the United States Weather Bureau at Topeka, Kans., in November and December, 1909. These are more representative of typical winter conditions as they were made mostly during a winter month and when outside temperatures were lower than those represented by Prof. Ward's data. Table 3 shows the results of Mr. Flora's observations reduced to daily values, and omitting several days on which only one observation was taken. The table in all cases, except December 31, represents the means of three observations, taken at 8 a. m., noon, and 8 p. m. An examination of these data shows that in this case, as in the other, there was practically no relation between the outdoor conditions and those prevailing indoors. In fact, an application of the "least square" statistical method of comparison to the temperatures shows a slight negative relation, with the probable error practically as large as the correlation coefficient. Table 4 shows the result of the individual observations in a comparative manner. It will be noted from this table that with an inside temperature of 73°, the outdoor readings ranged from 5° to 68°, and that 74° indoors compared with a range of −1° to 66° outside. In Table 5 we have grouped the outside temperature readings to correspond with the divisions given by Prof. Huntington in his Table 1. These comparisons speak for themselves and surely indicate that an attempt to carry a comparison of winter outdoor temperatures with unknown conditions inside, to the degree of refinement set forth in Table 1, is, to say the least, obviously questionable. What significance could a grouping of less than 20°, 20° to 32°, 33° to 45°, etc., have, when the temperature of the sick room (the only temperature condition that could affect the patient) probably was very infrequently below even 66°?

Some interesting comparisons may be made also between the indoor and outdoor relative humidity readings obtained in this series of observations. If we arrange the individual outdoor readings into groups, similar to those in Prof. Huntington's Table 6 (not here reproduced), namely, 0–55 per cent, 56–80 per cent, and 81–100 per cent, we find that 9 observations fell within the first group, 42 in the second, and 38 in the third. The means for the outside observations were 47, 71, and 92 per cent, respectively, but the corresponding inside values show no appreciable range, the averages for each of the first two groups being 27 per cent and for the other 30 per cent.

In this connection it may be of interest to note the result of some investigations that have been made on the effect of humidifying a school room on the intellectual progress of the pupils. (See *Science*, New York, June 2, 1917, **5**: 657–660.) In this experiment one group of pupils was domiciled during school hours in a room without humidification in which the relative humidity averaged about 28 per cent. The other group was kept in a room where the relative humidity averaged about 42 per cent. Mental tests were given each group at the beginning and at the end of the experimental period, which extended from December to March, inclusive, but these failed to show any difference in the work accomplished, although there was a slightly greater improvement in favor of the dry group. It may be noted also that a physical examination of the children at the beginning and at the end of the period showed similarly no apparent effect of the difference in the humidity conditions.

In considering the question of humidifying living rooms, it must be remembered that it is not feasible in cold weather to supply an amount of moisture suffi-

[4] See MONTHLY WEATHER REVIEW, May, 1917, 45: 231–233.

cient to raise the relative humidity to anything like that prevailing outdoors, owing to the annoying condensation on the windows or colder walls. In the experiments made at Topeka, Kans. (previously discussed) humidity observations were made also in living rooms in various parts of the city. It was found that when the indoor humidity was raised as high as 50 per cent in cold weather, the windows and even painted walls of the rooms were usually dripping with moisture. What would be the physical effect on passing from a room of this character into a piercing winter wind?

DISCUSSION BY AUTHOR.

Mr. Kincer's review brings up several points of much importance. For example, he points out that if the article in *Ecology* is correct, there "should be a marked contrast in the death rate between those sections of the country having humid climates and those characterized by dryness of the atmosphere, the comparison being to the disadvantage of the drier climates." This conclusion seems justified; it can not easily be tested, however, for many other factors, such as the degree of outdoor life, the relative ages of the population, the size of the cities, and the amount of manufacturing and other unhealthful occupations must be taken into account. Nevertheless, the statistics of three life insurance companies, which I have published in *Civilization and Climate*, page 184, show that when similar groups of "risks" are compared the death rate in the dry parts of the United States is decidedly higher than in the moister regions. Again, as I have shown in an article to be published shortly in the *Geographical Review*, the cities in dry regions—for example, Cairo, Mexico City, Madrid, and the cities of northern India—have much higher death rates than the corresponding cities in moister climates where the degree of progress is similar.

Another point raised by Mr. Kincer is the importance of the period preceding death and especially of the day when an illness is contracted. I agree with him entirely. He seems, however, to have overlooked the fact that I make comparisons between the death rate and the day when influenza was contracted in New York City. Furthermore, in a study of operations published in *The Modern Hospital*, Vol. XIV, No. 1,[1] I have shown that the climatic conditions, especially the humidity, on the day when operations are performed is much more important than on the day of death. I should have gone into the matter much more fully were it not that in the nature of things it is very difficult to determine just when a disease was contracted. The important point is that wherever it has been possible to examine the matter thoroughly, both the day of death and the day when a given ailment was contracted appear to show a close relationship to the weather. Presumably, the relationship is strongest on the most critical day of the disease, no matter when that may come. In this connection it may be noted that a study of millions of deaths described in *World Power and Evolution*, and in *Modern Medicine*, vol. 1, No. 1, shows that when the month is taken as a unit, the general relation between health and the climatic elements is the same as when the day is the unit. For example, except at high temperatures, the moister months regularly show a lower death rate than the drier months. This has nothing to do with the seasons, for it appears when a single month, such as January, is taken for a series of years.

[1] Reviewed in MONTHLY WEATHER REVIEW, May, 1920, 48: 279–280.

Still a third point is that if low temperature is the cause of deaths in winter, "we should have a progressive decrease in deaths from northern to southern limits of the country with the greatest number in the north central border States." This conclusion would be justified were it not that a study of some 9,000,000 deaths in France, Italy, and the United States shows that the human frame is much more sensitive in climates where there is little variation than in more rigorous climates. Hence the people in south Italy and New Orleans, for example, suffer severely in health under conditions of low temperature which would seem very mild and would do almost no harm to residents of the mountains of northern Italy or of Dakota.

In another place Mr. Kincer says that if a high temperature, such as an average of 75° within doors, is harmful, "we should expect to find the seasonal death rate reversed in northern and southern localities, Chicago and New Orleans, for example." That is, the highest death rate should come in Chicago in winter and in New Orleans in summer. This conclusion is not justified by the facts, for in both places the death rate from December to March is roughly 20 per cent greater than from June to September. Nor is it justified by anything that I have said. Whenever the average temperature departs far from 64° in either direction the death rate soon begins to show an upward tendency. People can do much to protect themselves, however, not only by regulating the temperature of dwellings, but by changing their mode of life, and by going out into the country and living out of doors in summer. In Chicago the great mass of ordinary people devote vastly more effort and expense to keeping warm in winter than to keeping cool in summer. In New Orleans the reverse is the case, in spite of the fact that the inhabitants are more sensitive to cold than are those of Chicago. Moreover, the Negroes who form so large a part of the population of New Orleans, not only are better adapted to hot weather than is the white man, but they flock cityward in winter, thus raising the death rate. In order to obtain a true comparison it is necessary to take cities of similar size, similar occupations, and as far as possible, of similar racial compositions. Moreover, the northern city should be far enough north to be largely free from the injurious effect of summer heat. No pair of cities satisfies these conditions, but a comparison of Minneapolis with Atlanta and Birmingham may be instructive. The following table shows the average number of deaths per day by months from 1913 to 1917. The northern city shows a maximum in January, while both of the others have theirs in June when the first heat of summer sweeps away a great many of the weaker parts of the community. This reversal between the north and the south agrees with the conclusions drawn from millions of deaths in a score of countries.

Deaths per day, 1913–1917.[2]

	Minneapolis.	Atlanta and Birmingham.		Minneapolis.	Atlanta and Birmingham.
January	133.9	151.3	July	104.4	171.8
February	126.0	173.5	August	98.9	154.0
March	128.2	173.3	September	102.7	146.7
April	125.0	158.2	October	102.9	143.6
May	120.7	171.3	November	109.7	157.8
June	101.4	183.2	December	123.0	162.0

[2] It is noted that July and August are the hottest months in Atlanta and Birmingham, both considerably warmer than June, yet in August the tabulation shows a death rate of 8 below the average for the year.—*J. B. K.*

Perhaps the most important feature of Mr. Kincer's paper is an attempt to show statistically the lack of relationship between outdoor conditions and the temperature and humidity within doors. I agree with him entirely that this is one of the points where further study is most needed. The only thing that has prevented a far fuller study of the matter is the absence of records and the lack of funds for carrying on observations. It would be most valuable if the Weather Bureau could keep thorough records of temperature, humidity, and variability in hospitals, offices, and other inhabited buildings, and make careful comparisons between these and the outdoor conditions. If Mr. Kincer's suggestion lead to this result, they may prove of great value.

In the present case Mr. Kincer uses two small series of observations—one, by Prof. Ward, including 20 days, and the other, by Mr. Flora, including 32 days as originally published. Both periods are too short to give final results. Mr. Flora's data, however, include 89 observations, for on most days he took records at morning, noon, and night. These give preliminary answers to two questions raised by Mr. Kincer: First, Is there a definite relationship between the amount of water vapor in the outside air and in the inside air in winter? Second, When the temperature out of doors rises in winter, is there a tendency toward unduly high temperature within doors? In discussing the first question, Mr. Kincer uses relative humidity as if it were an absolute quantity. It scarcely need be said, however, that relative humidity means nothing unless the temperature is also stated. Foreign students have sometimes criticized Americans severely for the importance which we apparently attach to relative humidity. We seem to them to make the tacit assumption that a relative humidity of 70 per cent, for example, at a temperature of 60° F. is comparable to a similar relative humidity at 10° F. In the first case, however, a cubic foot of air contains nearly eight times as much water vapor as in the second. While I have attempted always to state the temperature as well as the relative humidity, I realize that it would have been better to use the vapor content of the atmosphere. I am glad that Mr. Kincer's suggestions once more call attention to the matter, for we need a complete change of attitude.

If the data given by Mr. Flora and quoted by Mr. Kincer are analyzed in respect to the vapor content of the atmosphere, a close relation between the amount of vapor in the outside air and within doors is at once apparent. This is shown by the following table:

Grains of vapor per cubic foot of outside air.	Number of cases.	Grains of vapor per cubic foot of inside air.
0.00 to 0.50	6	1.39
0.51 to 1.00	12	1.64
0.01 to 1.50	21	2.05
1.51 to 2.00	17	2.22
2.01 to 2.50	8	2.62
2.51 to 3.00	6	3.00
3.01 to 3.50	7	3.24
3.51 to 4.50	7	3.73
Over 4.50	5	4.83

The first column shows the number of grains of water vapor in a cubic foot of the outside air as deduced from Mr. Flora's table. The next shows the number of observations, while the third gives the average number of grains of moisture per cubic foot in the inside air. The vapor content of the inside air increases with almost perfect regularity in harmony with the increase of the vapor content of the outside air. There can be little question that during the period of Mr. Flora's observations the amount of vapor within doors was a direct function of the amount out of doors.[3]

In respect to the second question, confusion has arisen between the effect of a moderately high temperature in winter when it lasts for some days and the effect of a *rise* of temperature. In the article in *Ecology*, which is reviewed by Mr. Kincer, and in various other places, I have endeavored to make it clear that these two conditions must be sharply distinguished. A relatively high outdoor temperature in winter in the northern United States is favorable unless the houses are kept too warm or unless people expose themselves unwisely. On the other hand, the rise from a low temperature to a moderate temperature is almost always accompanied by an increase in the death rate, as I have shown in *World Power and Evolution*, where 400,000 deaths in New York City have been studied in relation to the daily changes of temperature during a period of eight years. Mr. Kincer, if I understand him correctly, maintains that Flora's figures show no relation between inside temperature and the rise in the outside temperature. In order to test this I have taken Flora's data and have compared the indoor temperature with the changes in the outdoor temperature during the preceding 24 hours. The results appear below.

Change in outside temperature in 24 hours.	Number of cases.	Average inside temperature.
		°
Drop of over 10°	14	71.4
Drop of 4°–9°	10	73.2
Change of 3° or less	18	73.0
Rise of 4°–9°	22	73.9
Rise of over 10°	13	73.9

The first column shows the amount of change in temperature during 24 hours. The second shows the number of cases, and the third the average temperature indoors. While these figures are not quite so regular as the preceding set, it is clear that there is a fairly systematic rise from an inside temperature of 71.4° following a *drop* of 10° or more to an inside temperature of 73.9° when the temperature *rose* 10° or more. The work of the New York City Ventilation Commission shows conclusively that such a difference of 2.5° produces a strain upon the heart and hence upon the whole system. Thus, in this case as in the other, Mr. Kincer's attempt to apply a test by means of exact records furnishes valuable evidence in support of the conclusions reached in the article in *Ecology*.[4]

In regard to mental tests in the schools of New York City, I have elsewhere (*World Power and Evolution*) shown that various factors aside from humidity are concerned. A reexamination of this experiment which will shortly be published, indicates that judged by the effect of temperature upon patients undergoing operations in hospitals, the total effect on health produced by the slight humification of the rooms in the New York schools can scarcely be expected to have exceeded 1 or 2 per cent. This small figure arises from the fact that the humification raised the relative humidity only

[3] No question was raised as to the comparability of the outdoor and indoor absolute humidity, as it was realized that there must necessarily be a close relation in these so long as no additional moisture was added to the indoor air. Prof. Huntington, however, used relative humidity and not absolute humidity in his investigation, and these values were under discussion.—*J. B. K.*

[4] The question more particularly raised in this connection was the justification for the refinement of the tabulation of outside temperature data to which Prof. Huntington carried his comparisons. Eight divisions of temperature were made, mostly of 10° intervals. In the tabulation of indoor values here given, however, the absolute range, omitting the first case, is little more than half of a degree.—*J. B. K.*

from 29 per cent to 42 per cent, the mean temperature being 67°. Both of these degrees of humidity are much too low according to the results obtained from a study of pneumonia, operations, and deaths in general. Furthermore the children were subjected to the slightly humified air only about 24 hours per week, while during the other 144 they lived under the same conditions as did the children who were in the drier room. A difference of 1 or 2 per cent in health could scarcely be expected to be evident in mental achievement, especially in view of the fact that the gradings depended upon only a single examination. One child with a cold would be enough to upset the entire result.

The question of the practicability of humification is of great importance. In many places it is to-day impracticable to have the degree of humidity which would seem to be desirable. That, however, is no reason for giving up the attempt. If we need greater humidity within our houses for the sake of health, the thing to do is to devise new methods of obtaining it. Double windows, for example, make a great difference in this respect; so, too, do proper air spaces within walls. In conclusion, a word should be said about the physiological effect of going from a warm room with fairly high humidity to the cold outside air in winter. I, too, like Mr. Kincer, supposed at one time that this was injurious. In order to test the matter, however, I made inquiries among greenhouse men who, more than almost any others, are subject to such changes. To my surprise I was repeatedly met by the most positive statement that greenhouse men feel no ill effects from going from the warm, moist greenhouse air to the cold air outdoors, especially when the greenhouses are kept near the ideal temperature, say at 65°. This point, like many of those discussed here, opens another great field where our knowledge is slight and where much further study is needed.—*E. H.*

RELATIONS BETWEEN THE METEOROLOGICAL ELEMENTS AND THE NUMBER OF DEATHS FROM INFLAMMATORY DISEASES OF THE RESPIRATORY ORGANS, AT PARIS.

By LOUIS BESSON.

[Abstracted from *Comptes Rendus* (Paris Acad.), Oct. 11, 1920, pp. 686-688.]

Having drawn upon the *Bulletin hebdomadaire de statistique municipale* for figures regarding the number of deaths from diseases of the respiratory organs, the author has studied them in relation to the daily and weekly means of the principal meteorological elements as determined at the Montsouris Observatory. The diseases considered were acute bronchitis, chronic bronchitis, pneumonia, broncho-pneumonia, pulmonary congestion, and other affections of the respiratory apparatus, with the exception of phthisis. The record covers the 10 years 1904–1913, or 522 weeks.

Evaluating the population of Paris at 2,784,000 during the period in question, he finds that there was a weekly average of 142 deaths from these causes, but there is a marked annual variation. There is a maximum in the middle of February and a minimum at the beginning of September. There is a secondary maximum in the middle of April and a secondary minimum in the middle of March. There is a marked relation between the antepenultimate weekly mean of temperature and these deaths, the one curve being the inverse of the other. There is also a direct relation between the number of days of the week preceding the death upon which there were winds from the NNE. to E. and the deaths. Considering these two factors of temperature and wind direction, it is possible to eliminate their effects and determine a seasonal curve. When this is done, it is found that the first six months of the year have more deaths than the last, and that November is the most favorable, whereas January and April are the most unfavorable.

Humidity is only a secondary factor to these three, because it is dependent upon the direction of the wind. NNE. to E. winds are dry winds, and since there is an increase in the number of deaths following these winds, it may be said that the dry air is not favorable, a fact which does not justify the good reputation, as the author says, of the *petit froid sec*.[1]

The details of the study, of which this note is a summary, will be published later elsewhere.—*C. L. M.*

COLDS AND THEIR RELATION TO THE PHYSICS OF THE ATMOSPHERE.

By C. M. RICHTER, M. D.

[Author's conclusions reprinted from the *Medical Record*, New York, Dec. 6, 1913.

1. Acute coryza, commonly called a "cold," depends for its development primarily on an excess of moisture in the air we inhale.

2. It develops, therefore, principally during the cyclonic weather condition called a LOW, especially when a period of very dry weather has preceded a LOW and when, in consequence, the change from previous dry air to the incoming very moist air is most rapid.

3. The excessive and more or less continuous nasal secretion at the beginning of an acute coryza relieves the respiratory apparatus from the otherwise damaging effect of an overcharge of moisture.

4. A child's nasal mucosa and the hyperesthetic one are especially prone to suffer.

5. The "running of the nose" constitutes in part a physiological vasomotor action analogous to the profuse and more or less continuous perspiration of the outer skin, which sets in whenever air temperature and relative humidity transgresses certain limits and which forces thereby better conditions for evaporation.

6. Latent microbism becomes active on the mucosa only after these air conditions have favored its development for some time. Microbism is very rarely the primary cause of an acute coryza.

NOTE ON TWO EARLY PAPERS ON THE PATHOLOGICAL ASPECTS OF CLIMATE.

Dr. I. M. Cline, who was for over ten years professor of climatology in the University of Texas and connected during that time with the United States Weather Bureau, and now in charge of the United States Weather Bureau station in New Orleans, La., made two contributions to the climatology of Texas based on over twenty years' records of Galveston, Houston, and other places.* These papers were read before the Texas State Medical Association in 1895 and 1896 and were entitled "The Climatic Causation of Disease with a Chart Showing the Pathological Distribution of Climate in the United

[1] M. Th. Tommasina (*Comptes Rendus*, Nov. 8, 1920, p. 939-949) takes exception to the author's conclusion, which, he says, is based upon a statistical study which was not adequate, owing to the peculiarities of diseases of the respiratory organs.

*In "*The Monthly Bulletin of the Texas Weather Service*," November, 1890, to October 1891, Dr. Cline published studies on the comparison of daily mean temperature change, and departures from normal with the daily mortality from several diseases in Galveston, Tex. His data covered the years 1875-1889, inclusive. Similar studies, Dr. Clines believes, should be made in various parts of the country, thus affording a medical climatological survey which would be of great assistance to the physician in selecting the proper climate for his patient.—EDITOR.

States" [1] and "Influences of Climatic Conditions and Weather Changes in the Functions of the Skin." [2]

Dr. Cline undertook to investigate the relation between the causation and fatality of certain diseases and weather changes which take place from day to day, as these appear of greater importance than the seasonal changes on account of their suddenness and frequency which shock the system even when in health. Sudden weather changes are unfavorable to the successful treatment of most diseases, but in a few diseases certain changes prove favorable. Decided change in temperature excites the nerve centers and in exciting the vasomotor center disturbs the vascular system and causes the capillary vessels to become gorged and paralyzed, which is a cause for inflammation in the affected parts. The effect is pronounced in decided falls in temperature in localities where there is a large diurnal range and where there is a wide difference between sun and shade temperature. Dr. Cline discusses the whole question of the adjustment of the human organism to these various changes and the possible occurrence of local or general congestion.

Dr. Cline furnishes an interesting problem in discussing the relation between inspired and expired air and the state of the bronchial mucous membrane. The quantity of water given off from the system in the form of vapor in excess of that received during respiration depends almost entirely upon the temperature of the air inhaled. Assuming that the air leaves the body at a temperature of 98.5° F. and saturated with moisture, it would carry off from the lungs of a person of average size in one day 6,636 grains of water in the form of vapor. In localities, for example, having an average mean daily temperature of 32° F. during the winter and the average relative humidity 75 per cent, each cubic foot of air would contain about 5.1 grains of vapor of water. The amount of water taken into the lungs by respiration during 24 hours under these conditions would be 1,785 grains; while the amount exhaled, 6,636 grains, shows an *excess* of water *given off* from the system through respiration over that received amounting to 4,851 grains daily. The excess becomes greater as the temperature goes lower and less as it rises, while the per cent of moisture remains constant. To furnish the complement of water between the amount inhaled and that exhaled rapid evaporation takes place from the lining mucous membrane of the air passages and air cells of the lungs wherever such weather prevails.

The fluids from the pulmonary circulation which normally keep the lining membrane of the lungs moist contain more or less of the nonvolatile salts carried in solution in the blood.

An interesting conclusion by Dr. Cline follows: These salts are left as a deposit from the water carried out of the lungs during respiration in quantities depending upon the amount of salts in the blood at the time and the extent of the evaporation which takes place. He claims and cites authorities to show albumen will not pass through an animal membrane toward pure water, while it will pass to a solution of salt, and that the more rapid the movement of the fluid the greater is the amount of albumen which passes through to the salt solution. Hence an excess of saline solution on the mucous lining of the lungs favors the exudation of albumen into the air passages and air cells. Dr. Cline believes that this condition favors pulmonary disease in affording lodgment and a favorable environment for the growth of pathogenic organisms. Against such a theory it may be urged that whatever tendency there may be toward a concentration of salt in the lining membrane of the air passages would be met by diffusion or osmosis so as to preserve an equilibrium. Any momentary change would be quickly restored by the vast reserve in the general blood supply.

Albuminous substances may pass through an animal membrane if the salt concentration is sufficient to injure it; but it should be remembered that the common method of *separating* albuminous substances in solution *from* salts is by dialysis.[3]—*Guy Hinsdale.*

[1] Galveston, Tex., 1895, 23 pp.
[2] Galveston, Tex., 1896, 8 pp.

AUTHOR'S NOTES.

Notwithstanding Dr. Hinsdale's statements of conditions which appear against my theory regarding lung diseases, I believe that further research dealing directly with the human organism will substantiate the conclusions I have reached.

When the physical organism is normal in all respects the vast reserve in the general blood supply no doubt would quickly overcome momentary changes and prevent the formation of conditions in the lungs favorable for the lodgment and development of disease germs. However, when an individual is somewhat indisposed, as is frequently the case, the human organism does not function as nature intended and it is then that conditions develop in the lungs which favor pulmonary disease in affording lodgment and favorable environment for the growth of pathogenic organisms.—*I. M. Cline.*

THE INFLUENCE OF INFINITESIMAL TRACES OF NUTRITIVE SUBSTANCE IN THE HUMIDITY OF THE AIR UPON CONTAGION.

By A. TRILLAT.

[Abstracted from *Comptes Rendus*, Paris Academy of Sciences, t. 171, pp. 282-284, July 26, 1920.]

The author, having previously shown (*C. R.*, 170, 1529, 1920) that the mortality among mice exposed to contagion is much greater if the surrounding air is saturated at the time of exposure than if it is dry, has now repeated his former experiments, introducing into the humid air 1/1,500,000 part by volume of ordinary bouillon. Numerous experiments confirm the fact that the favorable influence of humidity upon the spread of contagion is markedly augmented by the presence of infinitesimal traces of such nutritive substance. It has been shown before (*C. R.*, 155, 1184, 1912) that the vitality of microbes in suspension in the atmosphere is extraordinarily sensitive to physical and chemical agents.

Now, in nature the humid atmosphere is rarely pure—there are present respired gases, and emanations from the soil, all containing solid matter in suspension. It is especially important in practical hygiene to get rid of all respired air, since the humidity and nutritive substance contained therein is highly favorable for the rapid multiplication of microbes and the ready spread of contagion.[1]—*E. W. W.*

[3] Cf. Hinsdale, Guy: Atmospheric Humidity, *Bull. of the Medico-Chirurgical College of Philadelphia*, 1911, pp. 1-5.
[1] Cf. MONTHLY WEATHER REVIEW, May, 1920, 48; 284.

EFFECTS OF THE WEATHER ON HUMAN HEALTH.

[Reprinted from *Memphis Commercial Appeal*, Nov. 23, 1919.]

There are certain persons whose physical feelings vary with the weather, and in certain diseases the weather plays an important part in recovery or decline. Dr. A. Campani, of Milan, classifies these into three groups: The first includes headache, sensations of heat, irritability, suppression of secretions, and hemorrhage of the lungs; the second includes intestinal catarrhal disturbances, sleeplessness, and loss of appetite; the third comprises rheumatic pains, pains in old scars, etc.

In the *Gazetta degli Ospedali e delle Cliniche* (Milan) he analyzes 24,528 cases, exclusive of contagious diseases, and shows that the morbidity is least in the windy periods, especially in winter, while the highest morbidity accompanies periods of cloudy skies. As a general rule, he says, the best conditions for health seem to be during or immediately after the great atmospheric convulsions and the fair weather that follows them. The morbidity is highest during the periods of stagnation preceding storms, with a constant temperature, generally rather above the mean, the sky cloudy, and only weak atmospheric currents. The greater the fluctuations in the temperature of the 24 hours the less the morbidity, especially when the humidity is high. The northwest winds in winter and the southwest in summer seemed to be the most favorable for health in general. The influence of the weather on the development of plants and crops is so evident that he is convinced that physicians may well study the subject in the interests of patients.

SUNSHINE AND HEALTH IN ENGLAND.

In the October, 1919, number of the *Quarterly Journal of the Royal Meteorological Society* (pp. 309–310) Mr. W. H. Dines discusses a statistical study of the relation between the death rate, temperatures, and sunshine in England. Between death rate and temperature, he finds, as one would expect, a large negative correlation coefficient in winter, and a large positive coefficient in summer. There seems to be no significant relation between the duration of sunshine and the death rate. He concludes his note with the statement that "England, notorious for its absence of sun, is one of the most healthy climates in the world, while very sunny climates, like Egypt and South Africa, have a distinctly high death rate."—*C. L. M.*

MUNICIPAL WEATHER SERVICE OF PARIS.

In a letter to the Chief of the United States Weather Bureau dated at Paris, July 22, 1920, Louis Besson, Chief of the Physical and Meteorological Service connected with the Division of Hygiene of the Préfecture de la Seine, states that his service has as its principal object the application of meteorology to public hygiene:

"* * * It also furnishes all useful information on meteorological phenomena which concern the Department of the Seine; and in addition contributes, within the limits of its means, to the progress of meteorology in general.

"Our pluviometric net is now reorganized. In a circle of about 17 kilometers radius we have 60 stations supplied with rain gages of the same type. It is possible to make detailed charts of rainfall.

"For temperature, the net is less complete and less homogeneous. We are gradually putting into service a number of small English shelters containing maximum and minimum thermometers which will be less affected by influences of location than those in our French shelters. The object is to study the important question of the influence of the city of Paris upon the temperature as related to wind direction—an influence which varies from point to point and which it will be useful to determine exactly."—*E. W. W.*

IRREGULAR ATMOSPHERIC REFRACTION AT HIGH ALTITUDES.

By ERIC R. MILLER, Meteorologist.

[U. S. Weather Bureau Office, Madison, Wis., Sept. 17, 1920.

SYNOPSIS.

Irregular atmospheric refraction is assigned as the cause of distortion and extinction of the image of the pilot balloon in the observing telescope after the balloon passed through a surface of velocity-discontinuity at altitudes of seven to ten thousand meters.

In the pilot balloon work at Madison, Wis., the author has been struck by the suddeness of disappearance of the balloon that often occurs with a perfectly clear sky. The observer's usual remark in these cases, "It was perfectly plain a moment ago, but I can't see it now," indicates that the fading out occurs in much less than the minute-interval between the reading of the theodolite circles, and probably in a few seconds.

During the present summer there have been an unusual number of flights in which the balloon ascended nearly vertically. Under this condition it has been noticed that the extinction occurred after a sudden change in the speed of the balloon. In some flights the extinction has been only partial, so that the balloon has been followed long enough to ascertain that the fading out was not due to the leaking of gas.

On several occasions, much less often than the extinction, the balloon has been observed to become double in the field of the telescope, so that the observer has been puzzled to decide which balloon to point on.

On August 25, 1920, Assistant Observer Wildeman, who was pointing the telescope, remarked a curious elongation of the balloon. The author, who was recording the readings of the theodolite circles, looked into the telescope and saw the balloon sausage shaped, and sidling across the field irregularly, like the helpless wriggling of the larva of an insect.

The exact circumstances have been noted in four of these instances, and the numerical data are given in Table 1, the graphs of the velocity and direction with reference to altitude appear in figure 1, and the distribution of pressure over the country at the times of these flights in figures 2, 3, 4, and 5.

TABLE 1.

Date.	Time (90th meridian).	Altitude.	Azimuth from south.	Altitude above horizon.	Phenomenon.
1920.		*Meters.*	°	°	
Aug. 14	8:06 a. m.	7,998	139	41	Became faint.
Aug. 24	8:14 a. m.	9,216	191	38	Do.
Aug. 25	7:59 a. m.	7,560	199	44	Distorted, sausage shape.
Sept. 2	8:25 a. m.	10,450	105	25	Lost 75 per cent brightness in a few seconds.

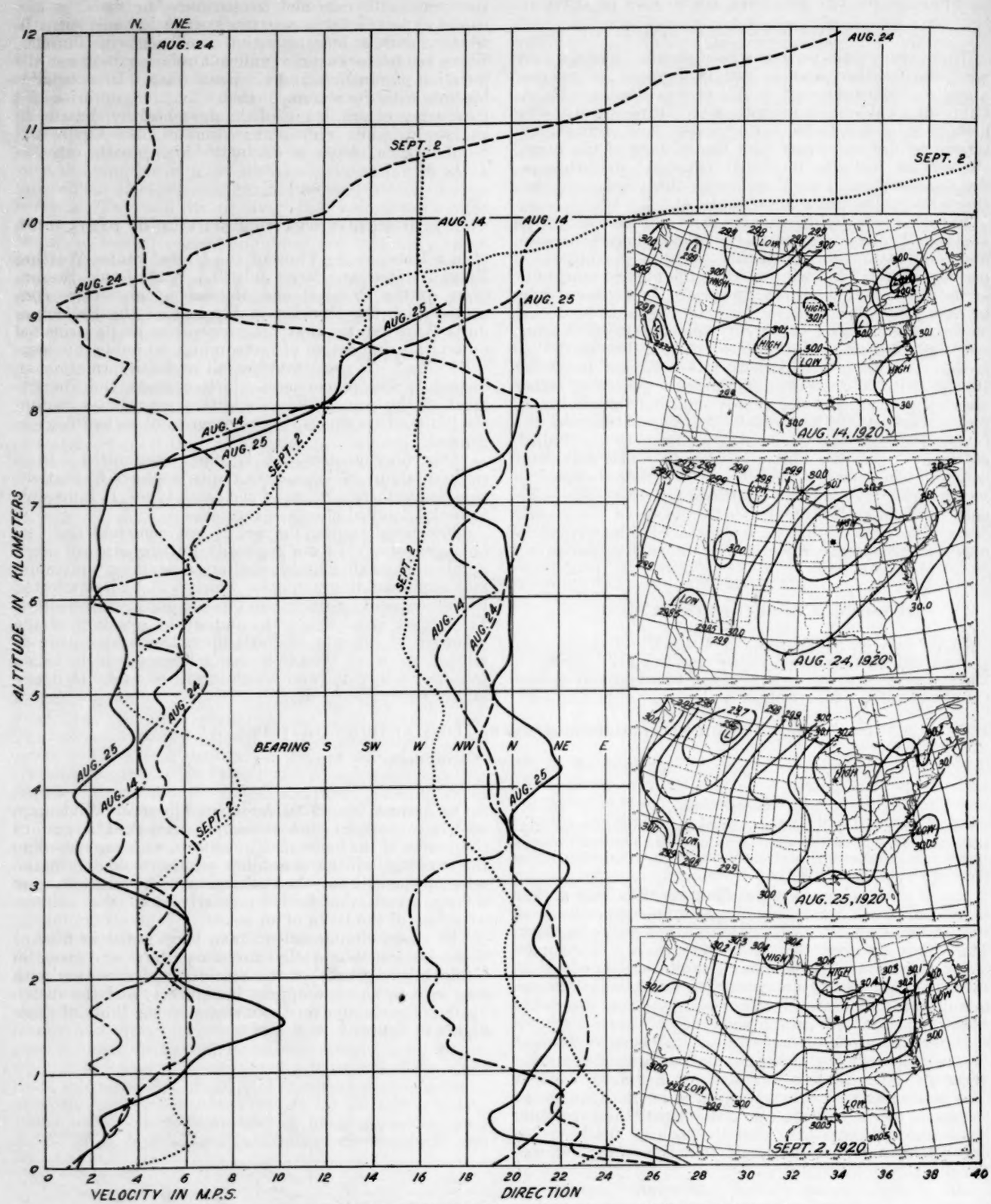

FIG. 1.—Changes of direction and velocity with altitude at Madison, Wis., with various distributions of atmospheric pressure.

On the afternoon of August 25 the balloon was followed to an altitude of nearly 20,000 meters. It became faint as in the morning, but as the altitude was not noted exactly it is not known how it was related to the changes in velocity of the balloon. The visibility of the balloon improved afterwards.

The altitude at which distortion or extinction occurred is marked on the graphs, figure 1. It will be seen that the disturbance occurred in each case after a sudden increase in the velocity of the balloon. The interval was small on August 14 (3 minutes), August 24 (1 minute), and August 25 (2 minutes), but longer on September 2 (7 minutes).

In the absence of temperature observations it is impossible to know whether the velocity discontinuity was accompanied by a temperature discontinuity, but if it were, then detached "lenses" of air of different temperature and density may have caused the observed disturbances of refraction.

Leaking would cause extinction of the balloon, and seeming increase in the velocity on account of the failure of the balloon to maintain the assumed rate of ascent upon which is based the calculation of the position of the balloon by the one-theodolite method used at Madison. The intervals of 10 and 14 minutes after the sudden partial extinction noted on August 14 and 24 during which the balloon was followed, and the speeding up of the balloon for 20 minutes before the sudden extinction on September 2, are thought to eliminate the possibility that leaking has caused the phenomenon here reported.

The possibility that the distortion of the balloon image on August 25 was due to eyestrain was eliminated by the change of observers. That it was not due to internal reflections in the optical system of the theodolite is proven by the wriggling motion of the balloon image.

THE RELATION OF TELESCOPIC DEFINITION TO COLD WAVES.

By W. H. PICKERING.

[Mandeville, Jamaica, June 21, 1920.]

Telescopic definition, or "seeing," as it is technically called, depends mainly on the currents located in our atmosphere up to an altitude of 3 or 4 miles. Their velocity is of little consequence, variations in their temperature forming the controlling influence. In the temperate zones a high barometer and cold wave are most injurious to the seeing; in the Tropics, the vicinity of a hurricane. The seeing is measured on a scale of 12, and is at its worst in Jamaica during the winter months, when the circulation of the temperate zone, with its westerly winds, sometimes reaches us. This it is especially liable to do at night.

The seeing is recorded here nearly every night when it is clear, and often several times during the evening. The upper graph in figure 1 represents the seeing during the three months of January, February, and March, 1920. The angles of the shaded regions indicate the dates when it was found to vary. The second graph indicates the readings of our minimum thermometer, and the short vertical lines at the bottom, the dates when a "high" in Florida or Georgia is found on the daily maps of the Weather Bureau.

An examination of the figure shows that there were seven periods when the seeing was inferior. These are indicated by the letters *a*, *a'*, *b*, *c*, *d*, *e*, and *f*. All cases except the second and next to last were followed by low minima on the second graph. In the latter case the minima were quite irregular. It will be noted that everyone of the five cold periods, *a*, *b*, *c*, *d*, *f*, was preceded by bad seeing. It therefore appears, as far as these observations go, that cooler nights can often be foretold about three days in advance by means of the upper air currents through their production of bad seeing.

In January and February every HIGH in Florida and Georgia was preceded by a low minimum in Jamaica. It did not seem necessary to letter all of them. Only 3 dates out of the 15 failed, namely, March 2, 27, and 30. The interval was usually two to three days, but the warning of bad seeing came nearly a week in advance. Whether a HIGH is found on the weather maps during the first four days in April the writer does not know.[1] This investigation suggests that the same general atmospheric drift that carries the hurricanes northerly in these longitudes, into our extreme southern States, carries the HIGHS as well.[2]

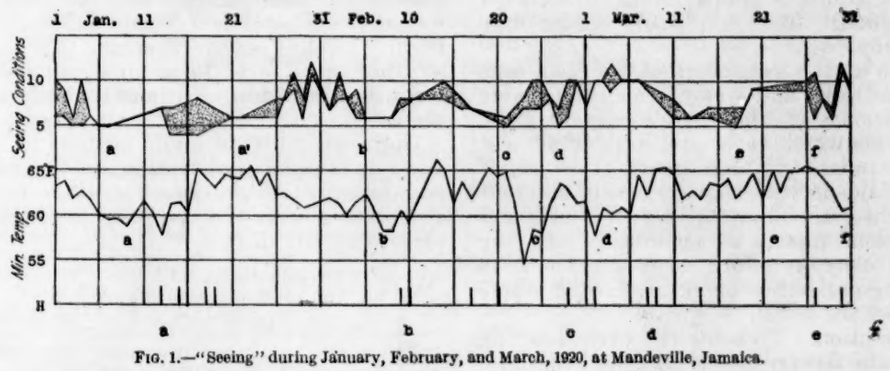

FIG. 1.—"Seeing" during January, February, and March, 1920, at Mandeville, Jamaica.

AN UNUSUAL LUNAR HALO PHENOMENON.

The accompanying figure 1 represents a lunar halo observed by Mr. A. A. Graham, about 8 p. m., September

[1] A weak HIGH moved across the South from the 1st to 3d, and was central in Georgia on the night of the 2d.—EDITOR.

[2] This explanation seems questionable, and the following connections more likely: With the passage of a LOW on the north, the cold winds on the back side first affect the upper levels and produce bad seeing, which is followed in two or three days by the arrival of the slower-moving lower winds at Jamaica, producing the minimum temperatures. In about three days more the HIGH which followed the LOW is, naturally, in the Southeastern States.—EDITOR.

20, 1920, 90th meridian time, at Topeka, Kans.. the observations being communicated by Mr. S. D. Flora, official in charge of the United States Weather Bureau station there.

The halos are stated to have been quite distinct, lasting almost an hour; no prismatic colors were visible; the line joining the moon with the point of tangency was parallel to the horizon; the relative diameters of the two arcs were merely estimated. The sky was to all appearances clear at the time, the halos apparently being formed in a sort of haze. Mr. Graham is stated to be a very keen and reliable observer of natural phenomena; no one else observed the halo.

No forms like these have ever before been reported. The closest approach to them are the infralateral and supralateral arcs to the 22° halo, observations of which are cited by Besson, MONTHLY WEATHER REVIEW, July, 1914, **42**, 444; they have never been explained. It seems desirable to put the present observation on record,

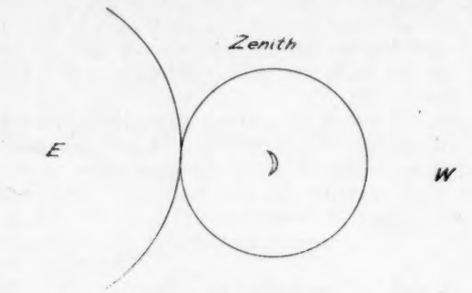

FIG. 1.—Lunar halo observed at Topeka, Kans., between 8 p. m. and 9 p. m., Sept. 20, 1920.

without making any attempt to interpret it.—*Edgar W. Woolard.*

WEATHER AND LITERATURE.

By ROBERT E. HORTON, Consulting Hydraulic Engineer.

[Voorheesville, N. Y., August, 1920.]

Literature owes much to the weather. It is nearly always the background, and sometimes the backbone, of pastoral prose and poetry. The Bible is filled with illustrations drawn from the aspects of the air. Thomson has made weather the theme of his "The Seasons." What would "The Midsummer Night's Dream" be without it?

Mark Twain claims the distinction of writing the only novel containing no weather, but even he did not venture to place the good nature of his readers under too great a strain, and so he added a compendium of assorted weathers as an appendix from which the reader may select to suit his fancy.

Three things make up the framework of the great outdoors: the rocks and soils and water, which determine the form and substance of the earth's surface; the organic or living forms which cover and inhabit it; and the air, which surrounds it. These appeal to lovers of the wood and open fields in various ways and to different degrees. To some the graceful molded forms of hills and valleys, the stupendous masses of mountains, and the appalling depths of canyons afford an exhilaration; to others they are mere curiosities of nature. Still others "have eyes, but they see not."

So it is with vegetation. To some the ever-changing verdure of the hills, the flowers of the field, and the lilies of the valley are things of beauty, interesting and inspiring in all their multi-varied forms and combinations. Others are like Peter Bell:

> "A primrose by the river's brim,
> A yellow primrose was to him,
> And it was nothing more."

Those who enjoy natural scenery in its broad magnificence, or its even more wonderful detail, or who rejoice in the life of vegetation, owe much of their enjoyment to the background of weather conditions. Measured in human generations, Tamalpais or Shasta or Ben Nevis is always the same mountain, but it has numberless and ever-changing aspects, according to the state of the weather in which it is viewed.

To some, weather is merely one of Nature's confirmed habits; to others it is an evanescent gown in which Nature's beauties are clothed—now fully revealed, now half concealed. Some persons derive a peculiar enjoyment—a feeling of kinship with Nature—from the experience of storms. Perhaps it is this feeling which keeps many a sailor at sea and many a voyager in the wilderness.

Artists seem to specialize in clouds and sunsets, partly because of their intrinsic beauty, but also because they lend themselves more readily to the brush than do other weather conditions. Poets often dwell at length on storms, and most of us stand at the door with reverent, uncovered heads, as "Announced by all the trumpets of the sky, arrives the storm."

It may be that one of the functions of literature is to stimulate the more refined sensibilities of man in the same way that the aspects of Nature exhilarate and invigorate them. In any event, Nature, as exemplified by the weather, must ever form an important element of descriptive literature. Without it the description is incomplete.

One need not read many authors to note great differences in weather description, as regards both accuracy and minutiæ. Minutiæ of weather conditions are not always essential. In the parable of the two houses the picture is fully drawn—

> "The rain descended,
> And the floods came down,
> And the winds blew and beat upon that house."

There are, perhaps, not many writers who can either describe or utilize details of weather conditions as well as Stevenson has done in "The Inland Voyage" and "Travels with a Donkey." Fortunately weather occurs in such endless varieties that impossibilities in events or their sequences are few, but it is to the positive, not to the negative, capabilities of the weather description as an ingredient of good literature that attention is called.

Some of us still have the old-fashioned idea that art in literature consists in painting a word picture that seems real. John Muir could portray a thunderstorm or snowstorm which Jupiter Pluvius and Mother Nature need not be ashamed to own as their child. The other extreme is found in the writings of those whose ability to utilize weather as a literary resource seems to go little further than besmutting the paper and leaving the rest to the imagination.

The argument seems never to be made that the study of good literature by a budding author debauches his natural style or dulls his imaginative faculties. So it seems reasonable to suppose that the quality of literary

weather would be improved if writers were given some training in the observations of weather forms and possessed some knowledge of weather causes. If writers will use, as needs they must, weather in amounts ranging from a modicum to a moiety in every outdoor scene, it is not improper to suggest seriously that meteorology, which is the science of weather, should have a place in the curriculum of *belles-lettres*.

Let no one be deceived by the notion that any meteorologist desires literary descriptions in the form of categorical scientific facts. The desire is rather otherwise—that good literature shall not be permeated by bad weather, but that, on the other hand, it shall be improved by the use of weather that simulates Nature—weather that appeals to him who knows what weathers are made up of. March winds are not always "raw," nor sunset skies always "imbued with a lurid glow." There are many phases of weather which, even if rare, have been occasionally witnessed by most persons and would be recognized if well described.

Again, meteorological metaphors are not undesirable, but, on the other hand, often facilitate the painting of a word picture in the most concise manner possible.

In Noah's flood "the fountains of the great deep were opened up and the windows of Heaven were opened." This tells briefly a story which would require many adjectives for an adequate description in a matter-of-fact way. Who has not been impressed with Nature's grandeur in the thunderstorm, when "with whipcords of lightning she drives the storm on." Here the metaphor is not strictly accurate, since in reality the storm generates the lightning; but the object of the metaphor is to create a true picture in the mind of the reader, and success is attained in a measure as the picture appears clean cut and correct, and the vehicle of the metaphor is forgotten.

In the use of better-defined weather types; accurate detail where detail is needed, and good metaphor where it will serve, as also in other ways, there are still opportunities for those who write to utilize weather descriptions that are not altogether trite and yet do no violence to Nature.

CLOUD NOMENCLATURE.[1]

By CHARLES F. BROOKS, Meteorologist.

Weather Bureau, Washington, D. C., Nov. 3, 1920.]

SYNOPSIS.

Cloud names closely defined are essential not only for the cloud observer but also for the cloud investigator. Since heights and the atmospheric processes responsible for particular clouds are not always known, the best basis for a nomenclature for general use is cloud appearance. The aspect of a cloud may be described in terms of form, coarseness, and density; and rather complete records can be made by recognizing the seven principal types of form, three degrees of coarseness, or apparent angular size, and five degrees of density. Such a system of keeping cloud observations is to be recommended only for those who have plenty of time and who wish to have great detail in their cloud records.

The general needs of meteorologists were recognized many years ago, as evidenced in the adoption of an International Classification of Clouds in 1896. This classification was simple and included aspects of form, coarseness, and density. Although the original classification was revised in 1905, the distinctions between several of the cloud forms were not closely drawn, and practically no provision was made for uniformity in detailed cloud records. As cloud forms occur in great variety the lack of names to indicate adequately the appearance of the sky has made cloud observations, in general, the least complete and the least accurate of any records of the important weather elements.

Pending further international revision an attempt is here made to provide for stricter differentiation of cloud forms, with the aid of a guide to identification. Particular emphasis is placed on the desirability of confining the name cirro-cumulus to ice clouds in order to prevent its present indiscriminate application to both the true, high cirro-cumulus and the appreciably lower, thin alto-cumulus. Differentiation of thin alto-stratus from cirro-stratus, and of nimbus from other rain clouds is also discussed. Revised wordings of parts of the International descriptions are suggested for consideration. Photographs* are not presented, for it is desired to place emphasis on the fact that the definitions form the ultimate basis for differentiation of forms.

The addition of 14 generally applicable subclasses, several of which already are widely used, to the present, simple International Classification is urged as an aid to greater detail and greater accuracy.

INTRODUCTION.

Cloud names are as necessary in the work of the meteorologist as rock names in that of the geologist or plant names in that of the botanist. To be widely serviceable, a system should invariably use the same name for the same kind of cloud and offer a sufficient variety of names adequately to describe the appearance of the sky. International agreement has already provided a fundamental nomenclature. As now used, however, different observers have various conceptions of the given types; and there is no uniformity in adding adjectives for describing certain cloud forms accurately.

CLOUD-APPEARANCE THE BASIS FOR CLASSIFICATION.

As a background for a discussion of the existing International Classification let us consider how cloud observations might be recorded were there no existent nomenclature and were there ample time at an observer's disposal. We are interested primarily in clouds as indicators of winds aloft, of atmospheric processes, and of future weather, and in clouds as sky cover affecting incoming and outgoing radiation. Horizontal movement and sky cover are recorded separately and are only in a minor degree involved in cloud form. But the name of a cloud should, if possible, give some indication of the atmospheric processes probably responsible for it, and also provide at least a partial basis for local forecast studies.

It would appear, then, that our classification of clouds should be based on cloud-forming processes. But how is one to know what processes are involved without being acquainted with the actual conditions in and about a particular cloud? A knowledge of meteorology, coupled with close observation of a cloud, may or may not provide unmistakable evidence of why there is a cloud and why it has such an appearance. Therefore, a classification by origin would be on an unsafe basis, especially since all observers do not study clouds with equal care nor interpret clouds alike, and since it should be possible to make a record without protracted observation. This leaves *appearance*, with, of course, all its indications as to height and origin, as the only safe and universal basis for cloud classification.

Form, coarseness, and density.—Cloud appearance may be described in terms of form, coarseness, and density. Since coarseness, or the apparent size of the elements and markings of a cloud, and density are matters of degree only, the primary differentiation of clouds must be based on form. The principal types of form to be seen

[1] Revised from paper presented at the meeting of the American Meteorological Society, Washington, D. C., April 22, 1920.

*A chart with 32 cloud photographs with legends conforming with this discussion will soon be issued by the U. S. Weather Bureau.

individually or in combination in clouds may be conveniently grouped in seven divisions, as follows:

1. *Fibrous*, characteristic of streaks of falling snow or rain as seen from a distance.

2. *Smooth*, characteristic of *sheetlike* clouds, especially when low, and when snow or rain is falling rather uniformly.

3. *Flocculent*, scaly, ice-cake like, or disk like, cloud elements in groups, which as wholes usually have smooth, curving outlines, which may be called *lenticuloid*, more or less lens- or lentil-shaped. When these curved outlines are markedly developed, and the clouds have the form of detached convex lenses, they are called "lenticular."

4. *Waved* or in *rolls*, characteristic of wave movements at or near horizontal boundaries between differing winds, or near the ground, and of lines where the wind at any level shifts to a new direction.

5. *Round-top*, characteristic of the summits of locally rising air masses.

6. *Down-bulged* or *round-holed*, characteristic of localized down-currents.

7. *Ragged*, characteristic of forming or evaporating cloud in a turbulent wind.

Any cloud defined in terms of form will have its aspect rather fully recorded, when the apparent size of each of its elements and markings, say, in such terms as *coarse*, *medium*, and *fine*, and when its density in such terms as *transparent*, *semitransparent*, *medium*, *dense*, and *very dense*, are noted. Thus, with seven names for form, with three degrees of coarseness, and five of density, we have an easily applied, compact, and, may I say, complete, basis for recording cloud appearance.

Experiment with cloud-recording in great detail.—Such a method of recording cloud observations was tried for 50 days, and was then abandoned, because (1) it was very time-consuming, even though requiring little thought or judgment; (2) the records were comparable only with difficulty, even though the mass of detail was in orderly form and in a relatively small compass; and (3) such a great number of combinations (about 3,000) were possible, that it was hopeless to devise satisfactory names for distinguishing one combination of detailed characteristics from another. As this strictly rational plan is impracticable for general use, let us consider the International Classification with the hope of modifying it to meet the need for greater explicitness and more detail, yet without departing from its fundamental and necessary simplicity.

THE INTERNATIONAL CLASSIFICATION.

History.—The following account of changes in the cloud nomenclature in general use since Howard, is quoted from (p. 317) in H. Helm Clayton's exhaustive chapter, a "Historical sketch of cloud nomenclature." [2]

Notwithstanding the numerous proposed systems of cloud nomenclature, none has to any extent displaced the system of Howard [1803], which gradually came into general use. Here a name like *fracto-cumulus* has been borrowed from Poëy [1865–79], there the name of mammato-cumulus has been taken from Ley [1879–83], and *cumulo-nimbus* from Weilbach [1880]; but in the main the system of Howard has remained unchanged except by natural growth. The International system of Hildebrandsson and Abercromby [1887] is, as stated by the authors, only an adaptation for general use of the cloud names which had already come into use in different places by gradual and slight changes in the system of Howard. Kaemtz [1831–36] added the name *strato-cumulus*, thus distinguishing a cloud form recorded by other observers with [as] cumulo-stratus. Renou [before 1877] added the name *alto-cumulus* to distinguish the low form of cirro-cumulus, or a cloud intermediate between cirro-cumulus and strato-cumulus. In Portugal the name *strato-cirrus* came into use to describe the lowest form of cirro-stratus, or rather a lower bluish or grayish sheet which had previously been recorded as cirro-stratus. It appears to correspond to Poëy's pallio-cirrus, and was given the name *alto-stratus* probably by Hildebrandsson [1887].[3]

The International Classification of Clouds was formed largely from the most widely used cloud names and definitions at the time of its compilation some 30 years ago. It was, necessarily, an agglomeration and a compromise. Clayton quotes an account [4] of how Abercromby obtained photographs of clouds all over the world and then went to Upsala to see Hildebrandsson. Of this conference Abercromby himself, writes:

> My primary idea—in which Prof. Hildebrandsson entirely concurred—was that the name of a cloud is of far less importance than that the same name should be applied to the same cloud by all observers; and also that the existing names should be retained, only that the form they are applied to should be more precisely defined.[5]

Existing cloud schemes, of which there were many in use in different countries, were worked over. Abercromby continues:

> Eventually, we agreed that 10 terms, all compounded of Howard's 4 fundamental types—*cirrus*, *stratus*, *cumulus*, *nimbus*—would fully meet the requirements of practical meteorology, with the least disturbance of existing systems * * *.

Hildebrandsson's statement about this system is quoted (p. 300) as follows:

> If one wishes to study the connection between cloud forms and the phenomena of the atmosphere, or to use these forms for prognostication, he must have a detailed terminology. * * * According to my view the next most important purpose of cloud observations is to determine the wind directions at different heights of the atmosphere. For that purpose it is not necessary to distinguish so many forms.

An atlas based on the Hildebrandsson-Abercromby system was published. The International Meterological Congress at Munich, in 1891, adopted this system as the International Classification.

Outline of the International Classification, adopted in 1891.[6]—

(*a*) Detached clouds with rounded upper outlines (most frequent in dry weather).

(*b*) Clouds of great horizontal extent suggesting a layer or sheet (suggestion of wet weather).

A. Upper Clouds: Average altitude, 9,000 metres (30,000 feet).

(*a*) 1. Cirrus.

(*b*) 2. Cirro-stratus.

B. Intermediate Clouds: Between 3,000 metres and 7,000 metres (10,000 feet and 23,000 feet).

(*a*) 3. Cirro-cumulus.
(*a*) 4. Alto-cumulus.

(*b*) 5. Alto-stratus.

C. Lower Clouds: Below 2,000 metres (7,000 feet).

(*a*) 6. Strato-cumulus.

(*b*) 7. Nimbus.

D. Clouds of diurnal ascending currents.

(*a*) 8. Cumulus: top, 1,800 metres (6,000 feet); base, 1,400 metres (4,500 feet).

(*b*) 9. Cumulo-nimbus: top, 3,000 metres to 8,000 metres (10,000 feet to 26,000 feet); base, 1,400 metres (4,500 feet).

E. High Fogs under 1,000 metres (3,300 feet).

10. Stratus.

N. B.—The equivalents in feet of the heights given in metres are only roughly approximate.

The definitions and descriptions of each form as adopted were translated into English in 1894, and were published

[2] "Discussion of the cloud observations," Ann. Astr. Obs. Harvard Coll., 1896, vol. 30, pt. 4, pp. 271–500, 17 pl., 4to., Historical chapter, pp. 279–331. Cf. summary of intermediate length in Am. Met'l Jour., July, 1894, 11: 83–96.

[3] The use of *alto-stratus* was broadened in 1905 enough to include the nonfibrous sheet-clouds at intermediate heights, although these are not specifically mentioned.

[4] Op. cit., p. 299: Abercromby, R., Suggestions for an international nomenclature of clouds, Quart. Jour. Roy. Met'l Soc., 1887, 13: 154–162, discussion 162–166, plate. This and an earlier paper, ibid., pp. 140–146, contain an illuminating discussion of the way in which descriptive names of clouds became associated with considerations of altitude and attendant weather phenomena.

[5] Quart. Jour. Roy. Meteorological Soc., Apr., 1887, pp. 148–162; quoted in Clayton, op. cit., p. 299.

[6] Quoted from "Cloud forms according to the International Classification." British Meteorological Office, London, 1918, M. O. 233, 10 pp., 17 pl. [from photographs by G. A. Clarke].

in the first edition of the International Cloud Atlas in 1895. Slight revisions were made at the International Meteorological Conference at Innsbruck, in 1905, and published in the International Cloud Atlas, second edition, in 1910.[7]

General remarks on cloud observing under the International Classification.—Most meteorologists have at one time or another made cloud records. Some have tried to use them. In making cloud records it is seldom easy to decide on the appropriate cloud names for the appearance of the sky; and, when the decision is made, one feels almost invariably that another observer might have made a different record. Anyone who thinks of using these cloud records recognizes that, unless made with special reference to certain features, they can be relied on only in a very general way as data in any investigation. This situation is not necessarily the fault of the observer, for in spite of careful study, perhaps memorization of the definitions of the 10 cloud forms, one can not describe the sky by using these 10 names without elaborating remarks, and, since only an enthusiast would be expected to make such elaborating remarks, the observer is likely to consider the attainment of accuracy in cloud observation as well-nigh hopeless and, therefore, not worth more than a minute or two during the limited observation period. When a given cloud might be called any one of three names, few care to split hairs in deciding which it shall be.

This situation may be improved, however, for, once granted that the 10 names are to cover *all* observed cloud forms, we are faced merely with the duty of defining where the dividing line shall be placed between the forms where they converge. To be sure, if some changes in the wordings of definitions and descriptions will remove ambiguity and make them inclusive to their limits, the presentation of such modifications is justifiable. Any such attempts to clarify, however, should rest on ideas rather generally held among cloud observers, as indicated by remarks on this subject published in various countries. The following definitions and descriptions, quoted from the International Cloud Atlas, second edition,[8] are approached, therefore, with the idea of delimiting the application of each name in accordance with accepted usage, and for some, to suggest such broadening or altering of definitions as appear to remove ambiguities and to make them inclusive yet explicit:

1. **Cirrus** (Ci.).—*Detached clouds of delicate and fibrous appearance, often showing a feather-like structure, generally of a whitish colour.* Cirrus clouds take the most varied shapes, such as isolated tufts, thin filaments on a blue sky, threads spreading out in the form of feathers, curved [or straight] filaments ending in tufts, sometimes called *Cirrus uncinus*, etc.; they are sometimes arranged in parallel belts which cross a portion of the sky in a great circle, and by an effect of perspective appear to converge towards a point on the horizon, or, if sufficiently extended, towards the opposite point also. (Ci.-St. and Ci.-Cu., etc., are also sometimes arranged in similar bands.)

The distinguishing characteristics of Cirrus are that it is *fibrous* and *detached*. Although cirrus clouds are usually high, the actual or apparent height is not involved in differentiating Ci. from other cloud forms.

2. **Cirro-stratus** (Ci.-St.).—*A thin, whitish sheet of clouds* sometimes covering the sky completely and giving it only a milky appearance (it is then called *Cirronebula*), at other times presenting, more or less distinctly, a formation like a tangled web. This sheet often produces halos around the sun and moon.

Cirro-stratus is generally distinguishable from alto-stratus and stratus by its thinness, whiteness, and by halos when present. Difficulty arises, however, in differentiating Ci.St.[9] from thin A.St. or thin St. when the latter are brilliantly illuminated by the sun or moon and within an angular distance of 90° of the luminary. Under such conditions slow change of form and density and, usually, relatively slow movement, characteristic of high clouds, identifies a thin, white cloud sheet as Ci.St. Thus, while Ci.St. is "*a thin, whitish sheet of clouds*," all thin, whitish sheets are not Ci.St.

Although the 10 forms are classified in an introductory section of the International Cloud Atlas according to their average heights,[10] should we allow height to be a criterion on which to base records of cloud form? In cold, winter weather a nebulous white sheet at a low elevation, perhaps even reaching the ground, may produce brilliant halos. Should it not be called Ci.St.? It certainly fits the definition of no other form. Furthermore, on blustery days with the temperature near freezing and with heavy ragged St.Cu. covering much of the sky, what should we call the thin, more or less irregular veil of snow—falling from these St.Cu.—which shuts out the clear blueness of the sky between the dense cloud masses? The snowflakes are too irregular and too varied in orientation to produce halos. There is a "thin, whitish sheet of clouds" undoubtedly composed of ice particles, as all cirriform clouds are; surely it is not the foglike stratus, nor a forming nor evaporating alto-stratus ("a thick sheet of a grey or bluish colour"), therefore it must be called Ci.St. if any name at all is applied to it. And if it is not named or otherwise mentioned, an important feature of the sky-aspect is omitted from the cloud record. It is fortunate that height is not stipulated in the International *definition* of cloud forms.

3. **Cirro-cumulus** (Ci.-Cu.), **Mackerel Sky.**—*Small globular masses or white flakes without shadows, or showing very slight shadows, arranged in groups and often in lines.*

Although some critics claim that cirro-cumulus clouds are neither cirrus nor cumulus, this comment is a relic of the time when *cirro-cumulus* included both our present Ci.Cu. and A.Cu. Clayton (pp. 293–294) quotes Clement Ley as follows:

They are, in fact, neither in appearance, nor in mode of physical formation, either compounds of cirrus with cumulus, or hybrids between cirrus and cumulus. Therefore, in practice, the use of the word "cirro-cumulus" has led to a large number of clouds of no great elevation being classed amongst the cirriforms; a result which was of little consequence when the laws regulating the upper currents of the atmosphere had received no examination, but which must prove absolutely fatal to a

[7] Paris, 1910, 4°, English section, pp. 9–16, 29 figs.
[The pictures in this atlas, and the way they are named as well as the definitions and elaborating remarks on cloud forms and their observation, have been subject to considerable criticism. See especially: J. Vincent, Notes bibliographiques sur les Nuages, Ann. Météorologique, 1912, Obs. Roy. de Belg., pp. 262–271; and C. J. P. Cave, The forms of clouds, Quart. Jour. Roy. Meteorological Soc., 1917, vol. 43, pp. 61–81.]

Important cloud atlases published since 1910 are as follows:
Loisel, Julien, Atlas photographique des nuages. Paris, 1911. 20 very good photographs. [A review by J. Vincent, 1912, loc. cit., states that this atlas is of great service to new men, and that it imposes on official organizations, international or otherwise, the revision of the clouds of the intermediate level.]
Taffara, Luigi, Le nubi. Part I, Testo; 67 pp., diagrs., ills. Part II, Atlante [26 pls.] R. Ufficio Centrale di Meteorol. e Geodinamica, Rome, 1917. 14 by 9½ inches.
[Comprises discussion of cloud photography, a history of cloud nomenclature, and a new detailed classification by the author, all types of which are illustrated in the plates, largely from the author's photographs. See review by R. DeC. Ward, in *Geogr. Rev.*, Oct., 1920, 10:276, and by D. Brunt in Quart. Jour. Roy. Meteorological Soc., July, 1919, vol. 45, pp. 258–259.]
[Clarke, G. A.] Naval meteorological service cloud atlas. Prepared by Hydrographic Department, Admiralty, under the superintendence of Rear Admiral J. F. Parry. [London] 1918. p. 1, 14 col. plates. 48½ by 39 cm. [Large colored prints of oil paintings by G. A. Clarke.]

[8] The booklet, M. O. 233, loc. cit., contains another set of definitions, now in official use by British observers. The following note explains:
"The translation into English has been altered in certain respects from that which appears in the English version of the introduction to the International Cloud Atlas in order to represent more closely the original French."
Since the English version in the International Cloud Atlas is official, there seems to be no call for American observers to use a translation of the French version. At any rate, the British Meteorological Office translation of the French version does not differ appreciably from that in the International Cloud Atlas.

[9] In U. S. Weather Bureau practice, hyphens are omitted from the cloud-name abbreviations.
It would be still simpler, and more saving of time and space to use the old Signa Corps abbreviations: C for cirrus; K for cumulus; N for nimbus, and S for stratus.—*General Instructions to Observers of the Signal Service*, 1887, pp. 55–56. These abbreviations are still in use at Blue Hill Observatory.

[10] See outline quoted on p. 514, above.

scheme based upon those laws, according to which new and most valuable results will be attained. The name "cirro-stratus" is almost equally objectionable, and for similar reasons.

Meteorologists soon sought to escape this trouble by giving the names *alto-cumulus* and *alto-stratus*, respectively, to the lower forms of the clouds formerly called "cirro-cumulus" and "cirro-stratus." In doing so, however, it was deemed sufficient merely to define Ci.Cu. as "small globular masses," etc., to distinguish it from A.Cu. which was defined as "Largish globular masses," etc. Unfortunately for the value of this distinction, however, forming A.Cu. often satifies exactly every point in the definition of Ci.Cu., and, therefore, is called Ci.Cu. We now know, what was apparently not known then, that the higher, true Ci.Cu. are invariably formed of ice, while the lower group, for which the name A.Cu. was exclusively intended, are usually composed in large part, at least, of water droplets. Distinguished on the basis of ice-crystal or water-droplet, Ci.Cu. and A.Cu. are not likely to be confused; the former can make no diffraction colors, corona, or irisation, in the vicinity of the sun or moon,[11] while the latter especially when so thin as to be commonly mistaken for Ci.Cu. on account of its fine structure (suggestive of great height), will produce brilliant diffraction colors. The fact that halos are not seen in Ci.Cu. is not a valid objection to the claim that they are of ice crystals,[12] for the lack of halo phenomena is a necessary consequence of the turbulence and unequal size of the crystals attending, respectively, the diverse vertical motions and the process of condensation responsible for the Ci.Cu.

Ci.Cu. is defined as "small." What should we call the rounded tops on cirrus tufts, when of medium or large size which top the Ci.St. and fibrous A.St. clouds overflowing from an intense cyclone? Although these are of snowflakes, like Ci.Cu., they seem to fit better the definition of A.Cu.

In view of these considerations, it would seem advisable to have the definition and description of Ci.Cu. read:

Cirro-cumulus (Ci.Cu.).—*Small white flakes or tenuous globular masses which produce no diffraction colors near the sun or moon.* The cloud units are usually arranged in groups and often in lines, suggestive of one or more sets of small waves. Ci.Cu. being composed of ice particles, are usually bright, in spite of their tenuity, and do not have the solid appearance characteristic of liquid-droplet, A.Cu. clouds. At times the tops of cirrus tufts or of Ci.St. sheets are capped with Ci.Cu."

4. **Alto-stratus** (A.-St.).—*A thick sheet of a grey or bluish colour*, sometimes forming a compact mass of dark grey colour and fibrous structure. At other times the sheet is thin, resembling thick Ci.-St., and through it the Sun or the Moon may be seen dimly gleaming as through ground glass. This form exhibits all changes peculiar to Ci.-St., but from measurements its average altitude is found to be about one half that of Ci.-St.

Differentiating A.St. from Ci.St. presents the same difficulties as the distinction between A.Cu. and Ci.Cu just discussed. Although the name *alto-stratus* was invented for the purpose of differentiating the lower section of the old cirro-stratus group from the upper, the International definition and description fails to provide adequately for this. Like A.Cu., it is described as a heavier cloud, which at times looks like its higher counterpart. In addition, however, the lower altitude of A.St. is mentioned. Thin A.St. is very commonly mistaken for Ci.St., and in much the same way that A.Cu. is mistaken for Ci.Cu.; the thin A.St. satisfies every point in the definition of Ci.St. Here, as in the case of A.Cu. versus Ci.Cu., the lower form can be identified by its more or less smoky appearance when more than 90° from the sun, and, often, by the changeable form and density of particular sections of the sheet, and by its production of coronas. The fibrous A.St., which is of snow, as is Ci.St., is merely a dense cloud, which if thinner would be Ci.St. Thus, fibrous A.St. is to be distinguished from Ci.St. by greyness, and, in case a halo has previously been seen with thickening Ci.St., by the disappearance of the halo (on account of the weakening of the light passing through the cloud, not because of any decreased refraction).

Other cloud observers have complained about the inadequacy of the definition of A.St. to meet the original intention of dividing the old "cirro-stratus" into upper and lower sections—the new Ci.St. and A.St. Thus, J. Vincent[13] objects to the incompleteness of the A.St. definition arising from the omission of any mention of nonfibrous A.St. and of those features of it, such as undulations and mammato forms, so commonly observed. Would not some such definition and description of A.St. as the following be more serviceable than the present International one?

Alto-stratus (A.St.).—*A sheet of grey or bluish color*, either generally fibrous or presenting a smooth, undulated, mammato, or frayed-hole appearance. Through the fibrous (snow-crystal) A.St. the sun or the moon may at times be seen dimly gleaming as through ground glass. On thin parts of the other (water droplet) kind diffraction colors appear in the vicinity of the sun or moon. Steady rain or snow may fall for hours from A.St.[14]

5. **Alto-cumulus** (A.-Cu.), **Great Waves.**—*Largish globular masses, white or greyish, partially shaded, arranged in groups or lines, and often so closely packed that their edges appear confused.* The detached masses are generally larger and more compact (resembling St.-Cu.) at the center of the group, but the thickness of the layer varies. At times the masses spread themselves out and assume the appearance of small waves or thin slightly curved plates. At the margin they form into finer flakes (resembling Ci.-Cu.). They often spread themselves out in lines in one or two directions.

A.Cu., especially when just forming and when higher clouds are absent, may apparently satisfy every point in the definition of Ci.Cu. Such A.Cu., however, usually has a solid appearance, not characteristic of Ci.Cu., and presents brilliant diffraction of colors in the vicinity of the sun or moon. Furthermore, thicker, shadowy parts of the same formation are usually present in other parts of the sky or develop within an hour or two. In view of what so often presents itself as undoubtedly A.Cu., why not reword the definition and description as follows: "Alto-cumulus (A.Cu.).—*Globular, scaly, or wave-like masses, white or greyish, partially shaded*, usually arranged in groups or lines, and often so closely packed that their edges appear confused. In the vicinity of the sun or moon diffraction colors are usually visible. At times the tops of large cirrus tufts or of Ci.St. or A.St. masses are capped with rounded domes of A.Cu., too large to be called Ci.Cu."

[11] The two parts of such a statement as the following are incompatible: "They [Ci. Cu are all composed of ice dust or crystals and may be prismatically colored when near the sun (Irisation)."—A. G. W. Howard, "The Clouds," on back of Aug., 1920, issue of monthly meteorological charts of the East Indian Seas, published by Brit. Met. Off. For discussion of this question of optics see p. 528–537 in W. J. Humphreys "Physics of the Air," Philadelphia, 1920.

[12] Cf. "It would appear that true cirro-cumulus is not composed of ice particles, for halos are not seen in these clouds . . ."—C. J. P. Cave. The forms of clouds, Quart. Jour. Roy. Meteorological Soc., 1917, vol. 43, pp. 61–82, 27 figs. (Quotation from p. 65.)

[13] Loc. cit. (footnote 7 above), p. 266.

[14] J. Vincent cites the omission of a mention of this fact as a reason for the widespread use of the synonym "rain-clouds" for "nimbus" (ibid.).

Clayton gave the name *alto-nimbus* to A. St. from which rain or snow is falling; and this is still in use at Blue Hill Observatory (Massachusetts).

The more or less confusing descriptive matter of the International text can then be omitted. A comparison with the definitions of St.Cu. and Ci.Cu. would be sufficient to reveal the facts that large, dense A.Cu. borders on the smaller St.Cu., and that thin, small A.Cu. must resemble Ci.Cu. in most respects.

6. **Strato-cumulus** (St.-Cu.).—*Large globular masses or rolls of dark clouds often covering the whole sky, especially in winter.* Generally St.-Cu. presents the appearance of a grey layer irregularly broken up into masses of which the edge is often formed of smaller masses, often of wavy appearance resembling A.-Cu. Sometimes this cloud-form presents the characteristic appearance of great rolls arranged in parallel lines and pressed close up against one another. In their centres these rolls are of a dark colour. Blue sky may be seen through the intervening spaces which are of a much lighter colour. (Roll-cumulus in England, Wulst-cumulus in Germany.) St.-Cu. clouds may be distinguished from Nb. by their globular or rolled appearance, and by the fact that they are not generally associated with rain.

It is well, perhaps, to point out that some St.Cu., unless in very large units, would be called A.Cu. if viewed from a depth of, say, 2 kilometers below the earth's surface. Correspondingly, a cloud formation which might be called A.Cu. by an observer in a valley, may be called St.Cu. by one on a mountain 2 km. higher. For many cloud observers, St.Cu. forms a convenient catch-all for any dense cloud that can not readily be classified otherwise. It should be recognized, however, that there is no more justification for calling such a cloud St.Cu. than for calling it something else, unless its characteristics are more nearly like those of St.Cu. as defined than like those of any other form.

Since the word "globular" carries the implication of sphericity, it might be better to use the words "disk-like or scaly" instead. Then the distinction between detached St.Cu. with its generally flat tops and Cu. with its dome-shaped tops would be more obvious.

7. **Nimbus** (Nb.), **Rain Clouds.**—*A thick layer of dark clouds, without shape* and with ragged edges, from which *steady* rain or snow usually falls. Through the openings in these clouds an upper layer of Ci.-St. or A.-St. may be seen almost invariably. If a layer of Nb. separates up in a strong wind into shreds, or if small loose clouds are visible floating underneath a large Nb., the cloud may be described as *Fracto-nimbus* (Fr.-Nb.) ("Scud" of sailors).

The raggedness and density of Nb. differentiates it from the sheetlike St. All rain clouds are not nimbus, and even those clouds from which a steady rain or snow is falling are not nimbus unless ragged edges are visible. Furthermore, there may be "rainless nimbus."[15] With regard to the wording of the definition and description, the words "Rain clouds" at the beginning, carry to many observers the implication that all rain clouds are Nb. (if not Cu.Nb.). The first sentence gives the correct conception, therefore, I think the words "Rain clouds" should be omitted. The last sentence, describing Fr.Nb. seems unnecessary, and it detracts from the strength of the definition of Nb. It is somewhat incongruous to have nimbus as "A thick layer of dark clouds, without shape and with ragged edges," and then to describe (thin) separated wisps as "fracto-nimbus." "Fracto" has the implication of being broken or ragged: and since nimbus is a ragged cloud, fracto-nimbus is thus a ragged ragged cloud. It is probable that no rain (except perhaps a light drizzle) ever falls *from* a piece of scud—the rain falls *through* it.

There are, perhaps, three subtypes of nimbus. One occurs with moderate to brisk, converging southerly winds. Long lines of cloud parallel to the wind direction grow and grow from ragged, though nearly horizontal, bases near the ground and lean forward aloft. The tops of these convectional clouds are probably invariably rounded, but they are not often seen from below. The International Atlas says that when such rounded tops are visible the clouds may be called *Nimbus cumuliformis*. A second (uncommon) type of nimbus develops from heavy fibrous A.St., with a rather coarse mammato structure, which, by the time rain falls develops into very large ragged masses with curved lines still predominating. A third type of nimbus may best be described as the dense, formless clouds characteristic of showery spring or summer days, usually with some thunderstorms (in Cu.Nb.).

Although many observers claim that there should be no such cloud as Nb. and that "nimbus" be used merely as a substantive, (cf. Ley, loc. cit., p. 74) I am strongly in favor of its retention, for it comprises a rather definite type of cloud which otherwise would merely make worse the present potpourri St.Cu.

8. **Cumulus** (Cu.), **Wool pack Clouds.**—*Thick clouds of which the upper surface is dome-shaped and exhibits protuberances while the base is horizontal.* These clouds appear to be formed by a diurnal ascensional movement which is almost always noticeable. When the cloud is opposite the Sun, the surfaces facing the observer have a greater brilliance than the margins of the protuberances. Then the light falls aslant, as is usually the case, these clouds throw deep shadows; when, on the contrary, the clouds are on the same side of the observer as the Sun, they appear dark with bright edges.

True cumulus has well defined upper and lower limits, but in strong winds a broken cloud resembling Cumulus is often seen in which the detached portions undergo continual change. This form may be distinguished by the name *Fracto-cumulus* (Fr.-Cu.).

Cu. is easily recognizable by the fact that it is *domed* and *detached*. This applies to clouds even when rain is falling from them. The International Atlas provides for such the name *Cumulus nimbiformis*. When the Cu. clouds, such as are characteristic of clearing weather with a northerly wind on a bright morning after rain has fallen, reach a level of little or no lapse-rate, or possibly an inversion of temperature, and their domed tops flatten, and sometimes spread[16] the clouds then are to be called St.Cu. Under such conditions, the newly forming clouds have the domed tops, and are Cu., while the older ones have become St.Cu.

9. **Cumulo-nimbus** (Cu.-Nb.), **The Thunder-Cloud; Shower-Cloud.**—*Heavy masses of cloud rising in the form of mountains, turrets or anvils, generally surmounted by a sheet or screen of fibrous appearance (false Cirrus) and having at its base a mass of cloud similar to nimbus.* From the base local showers of rain or snow (occasionally of hail or soft hail) usually fall. Sometimes the upper edges assume the compact form of cumulus, and form massive peaks round which delicate "false Cirrus" floats. At other times the edges themselves separate into a fringe of filaments similar to Cirrus clouds. This last form is particularly common in spring showers.

The front of thunder-clouds of wide extent frequently presents the form of a large arc spread over a portion of a uniformly brighter sky.

Cu.Nb., in brief, is the massive, composite cloud, usually[17] with a fibrous [snow], spreading top. While it usually harbors a thunderstorm, the occurrence of thunder and lightning within it is not an essential characteristic. In the matter quoted from the International Atlas there seems to be no need for the introductory characterizations, "The Thunder-Cloud; Shower-Cloud." The descriptive matter covers this fact. Just as with nimbus, the isolated appearance of these descriptive names implies to some observers that all shower clouds are cumulo-nimbus. Therefore, I believe that "The Thunder-Cloud; Shower-Cloud," should be omitted. In view of the erroneous and ambiguous impression conveyed by the

[15] Cf. Clement Ley: Cloudland, p. 108.

[16] The spread top sheet in such a formation is still called *cumulo-stratus* by many European observers, although this name was eliminated from the International Classification because of the liklihood of confusion with St.Cu. Cf. A. de Quervain, Beiträge zur Wolkenkunde, Met. Zeitschr., 1908, 25: 433-453 (ref. to p. 435).

[17] Cave would make it "always": loc. cit. p. 73.

words "false cirrus" applied in the first instance to clouds that are real Ci. or Ci.St., and in the second, to A.St. or Ci.St. scarfs, I believe that they should be omitted from the quoted matter above.[18] Furthermore, the definition and the sentence mentioning the occurrence of precipitation are sufficient to indicate what a Cu.Nb. cloud is. The last three sentences of the first paragraph seem to be extraneous and weaken the explicitness of the definition.

If this definition of cumulo-nimbus is to be followed, it is obvious from the following considerations that except under unusual circumstances the number of tenths of the sky covered by cumulo-nimbus can not be more than 3 or 4. When a Cu.Nb. cloud with a spreading top approaches the observer, is he to record, Cu.Nb. 1, Cu.Nb. 2, etc., till it covers the sky as Cu.Nb. 10? If so, the reader of the record, would have no idea of the appearance of the clouds except at the very start. On the other hand, if the observer after recording, say, Cu.Nb. 2, shifts to A.St. 4 and Nb. 1, we get an indication of what the clouds looked like, although unless we happen to find a record of thunder and lightning, or some explanatory notes, we may be misled into thinking that the Cu.Nb. cloud has disappeared.

10. **Stratus** (St.).—*A uniform layer of cloud resembling a fog but not resting on the ground.* When this sheet is broken up into irregular shreds in a wind, or by the summits of mountains, it may be distinguished by the name *Fracto-stratus* (Fr.-St.).

Of Stratus, Abercromby says:[19]

We now come to the second variety of clouds, to which the name of stratus is applied, because it always lies in a thin horizontal layer, like a stratum of rock or clay. Pure stratus has no sign of any hairy or threadlike structure except at the edges, for a stratum which shows much marking would be cirro-stratus, and has quite a different origin. Pure stratus is essentially a fine-weather cloud, and is especially characteristic of antityclones. One very beautiful variety is often seen during a fine night, then the cloud forms thin broken flakes, something like mackerel sky, from which, however, it is really quite distinct. In Howard's original work on clouds, "stratus" was applied to ground mist, but that idea is now entirely discarded by all meteorologists.

Stratus is the layer-cloud that closely hems in the sky. It is not necessarily uniform, however, and this characteristic, when present, is useless for differentiating St. from A.St. and Ci.St.[20] Neither do all St. clouds resemble a fog, as is evident from the Abercromby quotation, above. At times, St. forming by mixture on the nearly horizontal under-boundary of a relatively warm wind will present a mammillated or undulated appearance, or, if condensation takes place in the lower as well as in the upper wind, an aspect not unlike a ragged, inverted, choppy sea. The low height by which thin St. may be differentiated in questionable cases from A.St. or Ci.St. is evident from the visible motion within the cloud, and the usual rapid progress across the sky. Thin St. forms coronas about sun or moon, and at more than 90° from the sun or moon looks more or less smoky. *Lowness* and *flatness* are the essential characteristics of St., therefore, why not define it as "A low [21] layer of cloud"? and add, "St. is distinguishable from A.St. only by whether or not it appears to be lower than 1,000 meters above the surface."

In the sentence about Fr.St., the words "in a wind, or by the summits of mountains" are not only unnecessary, but preclude considering as Fr.St. ragged evaporating remnants or first-forming wisps of a St. cloud when there is practically no wind.

Fr.St. is indistinguishable from Fr.Cu., and Fr.Nb. except by its associations. In view of the fact that forms other than Cu., St., and Nb. have ragged aspects at times, it would seem best to abandon the limitation of "Fracto" to only three and recognize it as applicable to any cloud type.

TABULAR GUIDE TO CLOUD IDENTIFICATION.[22]

Bearing in mind the considerations brought forth in this discussion, the following tabular guide to cloud identification has been constructed. This guide is serviceable whenever an observer can describe a cloud or group of clouds at the same level in terms of form, coarseness and density.

Characteristics.	International cloud forms.									
	Ci.	Ci.St.	Ci.Cu.	A.St.	A.Cu.	St.Cu.	Nb.	Cu.	Cu.Nb.	St.
Fibrous	x								x[1]	[6]
Sheetlike	(*)	x[2]		x		x		(*)		x
Smooth	(*)		(*)			(*)		(*)		
Lenticuloid							(*)			
Flocculent	(*)	(*)	f	(*)	[f][3]m	c	(*)	(*)		fm[7]
Rolled	(*)	(*)		(*)		x	(*)	(*)		(*)
Undulated							(*)	(*)		
Round-top	(*)	(*)	f	(*)	[f][3]m[c4]	c		c[5]	c	(*)
Down-bulged										
Ragged							c		c	
DENSITY.	[*Usually all bright.*]				[*Gray or shadowy, at least locally.*]					
Nearly transparent										
Semitransparent										
Medium		(*)	(*)							
Dense	(*)	(*)	(*)							
Very dense	(*)	(*)	(*)							

Legend: f=fine, m=medium, c=coarse, in angular size as seen from the ground. x may have any angular size. Where one letter or group of letters appears twice under a single heading such a cloud-form has one or the other characteristic and where there are different letters on separate lines it has one of the characteristics marked by letter as well as one marked by the other letter. Thus, St. Cu. has layer or roll structure, and also is either flocculent or round top. (*) indicates that the cloud named can not have such a characteristic.

A blank shows that the cloud may or may not have the indicated characteristic.

[1] Almost always fibrous top.
[2] Often with halo—no halo with any other form except Ci., and, rarely, Cu.Nb. top
[3] When fine, with diffraction colors when near sun or moon.
[4] Only when topping Ci., Ci.St., or A.St.
[5] Base horizontal.
[6] Fibrous only when like more or less interlaced fibrous bark cloth.
[7] Distinguishable from A.Cu. by lowness and sheet-like aspects of the formation as a whole.

[18] A. de Quervain, loc. cit., gives, on pp. 442-443, an historical account of "False Cirrus," essentially as follows:

"False Cirrus" came to be applied early apparently to the [scarf] cloud [see MO. WEATHER REV., July, 1917, 45: 361-3 3], and it has since been shifted to include both [scarfs] and the Ci.St. tops of Cu.Nb. In 1887, Köppen called attention to altitude measurements by Ekholm and Hagström which showed the altitude of "False Cirrus" to be 3,900 meters, 5 observations)—much lower than Ci. In 1889 (Met. Zeitschr., p. 443) Hildebrandsson gave the following definition: "When this cloud form is well-developed, it looks like sheet of Ci. or Ci.St. [Pseudo-cirri of the A.Cu. level or lower were not so carefully differentiated then as now.—A. de Q.], which sheet the great Cu. peak frequently pierces or forms itself into a cirriform sheet." Later Swedish observations showed Ci.St. tops at 6,600 meters average altitude, and 9,000 meters maximum. Nevertheless, "False Cirrus" is still generally considered to be low. The Potsdam observations of the International Cloud Year confused [scarfs] with Ci.St. tops, but those which were surely one or the other give the following averages and extremes:

[Scarfs] and caps: mean 4,140 m.; max., 6,470 m.; min., 2,890 m.
Ci.St. overflow tops: mean 7,120 m.; max. 9,400 m.; min. 6,290 m.
min. 2,900 m. (spring squall).

The name "False Cirrus" ought to come out of the International definition of Cu.Nb. Möller, 1890 and 1906, described the two forms, but explained them as owing to the same causes. Never does a Ci.St. top grow out of a cap (or scarf) form; though they may occur practically together and be intermingled.

Cave, loc. cit., p. 74, does not help to clarify the situation when he says that veil [scarf] cloud is to be differentiated from false cirrus.

J. Vincent, loc. cit., decries the addition of "False cirrus" as a characteristic of Cu.Nb, since Cu.Nb. is nothing other than a Cu. cloud that has made a great development, and since scarfs and snowing caps are not differentiated. He also complains of the use of "cumulus," in the name "mammato-cumulus" which surely is not cumulus, but usually is a feature of an A.St. cloud.

See also: Staikoff, St. D., Ueber die Natur der Gewittercirren, Met. Zeitschr., 1908, p. 361; Osthoff, H., Streifenwolken, ibid., 1907, p. 534; Kassner, C., Gewitterschirm und Sonnenringe, ibid., 1907, p. 301.

[19] "Weather," London, 1887, p. 82 (quoted by Clayton, pp. 324-325).

[20] Cf. Vincent, loc. cit.

[21] The omission of "low" from the International definition is deplored by A. de Quervain in his review of the International Atlas (Met. Zeitschr., 1912, pp. 189-190).

[22] There is "A guide to the identification of cloud forms," published in "The Observer's Handbook," Metl. Off., London, 1915, pp. XXXIV-XXXV. It is arranged after the manner of organization charts. There are three groups, headed "Clouds seen mostly in plan," "Clouds seen mostly in elevation or profile," and "Low clouds seen in plan or elevation according to circumstances."

USING THE INTERNATIONAL CLASSIFICATION FOR DETAILED OBSERVATIONS.

Is there not a way of using the International Classification so as to show details of cloud appearance to any extent needed? H. H. Clayton's detailed system has not been widely used because of its unwieldy Latin names.[23]

The most important of his subclasses; and a few new ones, however, can be given descriptive English adjectives or otherwise briefly described, and these can be designated in cloud records by exponential letters which are in many cases identical with those used by Clayton: *f* (ragged), *t* (thin), *n* (rain or snow falling from cloud, whether or not precipitation reaches the ground), ⌐ (part of, or derived from, thunderstorm cloud), *r* (roll cloud), *s* (smooth), *g* (very fine texture), *c* (tall relative to width), *l* (lenticuloid, i. e., with part or all bounding lines like the smooth curves of a lens),[24] *m* (mammillated), *u* (undulated), *b* (in bands or streaks), *z* (in zig-zags, or with marked angles in lines—fibrous clouds only), *d* (detached units—not needed with Ci. and Cu.).

Thus, St^{f} represents fracto-stratus; $A.Cu.^{t}$ disk-like, or ice-cake form, alto-cumulus; $A.St.^{sn}$ smooth alto-stratus from which rain or snow is falling.

The use of one, two, or three of the international names for different parts of the same cloud sheet, adds greatly to the possibility of expressing adequately the appearance of the clouds.

CONCLUSIONS.

1. Cloud-records to be comparable should be based on the appearance of the clouds as seen from the ground. If (as we can not) we could always know the origin of a cloud, a classification on the basis of origin would be preferable. The elements of cloud appearance may be recorded without naming cloud types; but for discussion names are necessary.

2. International agreement has provided a set of 10 cloud names to cover all cloud forms; but the definitions of these 10 do not include all cloud forms, nor do they differentiate them adequately. The chief sources of trouble are as between the following pairs: Ci.Cu. and A.Cu., Ci.St. and A.St., Nb. and other rain clouds, and, perhaps, St.Cu. and St. or A.St. If Ci.Cu. as defined is confined to ice-clouds, the frequent misnaming of A.Cu. will be eliminated. If it is generally understood that A.St. may be either a more or less dense fibrous, mammilated or smooth cloud of snowflakes, or a smooth, undulated, or mammilated water-droplet cloud, which is sometimes as thin and white as Ci.St., our difficulties on its score will be largely removed. If it is recognized that *nimbus* is the name of a cloud form, and not a synonym for the occurrence of precipitation, much further trouble will be prevented. Finally, if St.Cu. is always thought of as strato-*cumulus*, there will be less of the indiscriminate misnaming of irregular St. and A.St. With these and other difficulties removed it is possible to construct a tabular guide which will indicate which one of the 10 names to apply to any cloud that an observer can describe.

3. A vocabulary of 10 words, is, however, rather limited for recording and discussing the manifold aspects of the sky. The inadequacy of the language of some African tribes has contributed in no small degree to holding them at the bottom of the culture scale. On the other hand, the wide range of expression and shades of meaning allowed by the English language has been a decidedly favorable factor in the rise of English speaking peoples to their present position in the world. Let us adopt a set of standard characteristics, such as: Mammillated, ragged, undulated, etc. If, in addition, we make separate notation of density and actual, computed, or probable height, our cloud records will give a real indication of the aspect of the sky, and will thus complete the weather-picture provided by instruments, meteorographs, and pilot balloons.

[23] Op. cit., pp. 332-349, ch. 2, "A new detailed nomenclature of clouds, founded on the International nomenclature." Clayton's reasons for proposing these new details were: That they were needed for exact scientific studies, for descriptions of special occurrences, for meteorological observatories where observations are made, and for the use of specialists. His basis was form, altitude, and origin, as compared with Howard's basis of form only, and the International basis of form and altitude (A.Cu. vs. Ci.Cu., A.St. vs. Ci.St.). Although Clayton mentions origin in the cases of Cu. and St., he offers no change in names in consequence. "As the knowledge of the causes of special cloud formations increases, however, increasing weight will no doubt be given to cloud origin in determining classification and nomenclature." With this, the classification becomes one of form and altitude, therefore, much of the chapter is devoted to cloud altitudes. He evolves a detailed system which may serve the specialist who has plenty of time in which to apply it, but the large number of special forms and their Latin names will always cause it to be avoided by all but a very few enthusiasts.

[24] Not usually applicable to Ci., Ci.Cu., A.Cu., St.Cu., Nb., Cu., or Cu.Nb. The use of the word *lenticular* with Ci.Cu. and A.Cu. is common, in spite of the fact that most lenticular clouds are A.St. (cf. J. Vincent, loc. cit.).

ACKNOWLEDGMENT.

For months Mr. S. P. Fergusson has been giving me the benefit of his years of familiarity with the growth of the International Classification and with the detailed observing of clouds at Blue Hill Observatory. I wish to acknowledge gratefully his many suggestions, especially his service in checking tendencies to deviate too far from well-tried practice.

How to make and reduce detailed cloud observations and the use of a new form for cloud records will be presented in a later paper.

LAYER MEASUREMENTS OF SNOW ON GROUND NEAR SUMMIT, CALIF.

By H. F. ALPS and O. H. HAMMONDS.

[Weather Bureau, Reno, Nev., Oct. 9, 1920.]

The layer measurements were made in the open park, about one-fourth mile in a southeasterly direction from the railroad station at Summit, in the same place and in the same manner as during the preceding season. From our experience in this work during the past four seasons, it is believed that this park affords an ideal location for layer measurements of the snow cover.

Only four trips to the Summit were made, on account of the long interval between the first and second general storms in the mountains. The first measurement of the snow cover was made on December 31, 1919. At that time, the depth of the snow was 39 inches, and the ground was frozen to a depth of one inch. The top layer of the snow was slightly granular, due to surface melting. As the snowfall was light in January and the first half of February, the second trip was made on March 5, 1920, when the depth of snow on the ground was 68 inches. The old snow, the greater part of which fell in December, was 35 inches in depth with a 10-inch crust which would support any ordinary vehicle. This

accounts for the great difference in density between the third and fourth layers, as shown in the chart which accompanies this report. The ground was well moistened and not frozen. No drifting effects of the snow were noticed. The third set of measurements was made on April 13, when a total depth of 66 inches of snow was found. The depth of the old snow as clearly shown by the crust was 29 inches. The thickness of the crust varied from 8 to 12 inches, and contained scattered layers of practically solid ice two inches in thickness. The ground was moist and soft but not wet. The last trip of the season was on May 13, when the depth of the snow was 36 inches. The depth of the old snow was 11 inches, the crust of which was hard and icy. There were three icy layers in the old snow, each being from one to two inches in thickness. At places, these crusts nearly united. A coating of about one-quarter inch of ice covered the ground under the snow, and the ground was wet but not frozen. The snow was very granular.

TABLE 1.—*Average densities of foot layer measurements of snow based on records for four seasons.*

Month.	December.	January.	February.	March.	April.	May.
Ground foot	34	38	43	45	49	55
Second foot	31	34	38	42	48	52
Third foot	32	34	35	48	49	55
Fourth foot	27	30	32	40	47	.....
Fifth foot	13	32	31	38	51	.....
Sixth foot	.....	28	28	37	48	.....
Seventh foot	.....	18	25	35	51	.....
Eighth foot	.....	.....	31	33	55	.....
Ninth foot	.....	.....	29	32	50	.....
Tenth foot	.....	.....	28	30	.....	.....
Eleventh foot	.....	.....	25	26	.....	.....
Twelfth foot	.....	.....	31	19	.....	.....
Thirteenth foot	.....	.....	13	17	.....	.....
Fourteenth foot	.....	.....	.....	10	.....	.....

NOTE.—Measurements taken at Summit, Calif., elevation 7,019 feet, for the four seasons, 1916–17, 1917–18, 1918–19, and 1919–20.

The snowfall during the past three seasons was below normal; therefore, measurements of the snow cover during a few seasons of heavy snowfall are much desired.

LIFE HISTORY OF TROPICAL STORM IN LOUISIANA, SEPTEMBER 21 AND 22, 1920.

By ISAAC M. CLINE, Meteorologist.

[Weather Bureau, New Orleans, La., October 20, 1920.]

SYNOPSIS.

The tropical storm which appeared in the Caribbean Sea September 18, crossed the Gulf of Mexico during the 19th and 20th, and moved northward over Louisiana during the 21st and 22d, presents several features of unusual interest. It followed a course out of the ordinary for storms that move over Yucatan, and advanced with unusual rapidity. The storm was not of great intensity except near the center. We have more complete cloud, wind, and pressure records in the area traversed by this storm than have been available for study in any previous storm and these make its life history important in our search for knowledge of tropical storms. The lowest barometer reading after the storm passed inland was 28.99 inches at Houma, La. The depression began to decrease in intensity immediately afterwards. The observed tides were in conformity with the movement of the storm.[1] Warnings were distributed which were instrumental in saving lives and property. There was one death; and property damage was about $1,450,000.

GENERAL METEOROLOGICAL CONDITIONS.

The special meteorological features preceding and attending this storm are given for New Orleans, La., Mobile, Ala., and Pensacola, Fla., stations to the right of the line over which the center of the storm advanced; and for Galveston, Houston, and Port Arthur, Tex., stations to the left of that line.

The clouds of the cirrus type at New Orleans, La., Mobile, Ala., and Pensacola, Fla., stations to the right of the line along which the center of the storm was advancing were from W. on the morning of the 19th, changing to SW. about noon and continuing from that direction while visible during the 20th and 21st, except that at Pensacola, Fla., at noon and 7 p. m. of the 21st they were again visible through the stratus clouds moving from the SE. As the storm receded and curved to the westward, they were reported as moving with the stratus from SE.

The clouds of the cirrus type appeared at Houston, Tex., to the left of the line along which the center of the storm was advancing on the morning of the 20th, coming from SSE.; they were from S. at noon, and SE. during the 21st and 22d.

The only cirrus clouds observed at Galveston, Tex., consisted of a very few fine wisps visible in the SE. about 8 a. m. at an elevation of about 10° with no apparent motion.

[1] See MONTHLY WEATHER REVIEW, March, 1920, 48: 127-146.

PRESSURE IN THE DIFFERENT PARTS OF THE STORM.

Excellent barometer records have been obtained from a number of places well distributed over the area traversed by the storm. The aneroid barometers have been checked with the Weather Bureau barometer and the largest difference was ±0.07 of an inch. The proper corrections have been applied and it is believed that the observations represent the true conditions.

Complete barometer records covering the territory over which a cyclonic area has traveled are not usually found and they furnish interesting and valuable material for use in the study of a tropical storm moving into extratropical regions where the weather conditions at the time are practically the same as those that prevail in the tropics. The lowest pressure, 28.99, was reported from Houma, La., about 30 miles inland from the nearest coast line at 10:15 p. m. on September 21st; the next lowest was 29.09 at 11:20 p. m. at Morgan City, La., 10 miles to the north and 30 miles to the west of Houma. The next lowest was 29.13 at Bayou Goula, La., at 12:30 a. m. of the 22d, 80 miles from the coast. The topographical and physical features of the country for 50 miles from the coast are such that the hurricane, while traversing this area, retained the characteristics which it had in the open Gulf, and the wind and pressure conditions at Grand Isle, Morgan City, and Houma, represent the full intensity of the storm.

The cyclonic area commenced contracting and filling up on its outer rim soon after moving inland, as is shown by the comparison of the lowest pressure at Grand Isle and New Orleans, points about equidistant from the line over which the center of the storm advanced. At New Orleans, 50 miles farther along the line of advance than Grand Isle, the lowest barometer, 29.53, was 0.20 of an inch higher than at Grand Isle, 29.33. Near its center the storm did not diminish in intensity so rapidly. This is shown by the lowest barometer, 75 miles west and 20 miles farther north than New Orleans, at Bayou Goula, 29.13 inches. Bayou Goula is 50 miles farther along the line over which the center of the storm advanced than Houma, and the barometer near the center of the storm shows a rise of only 0.14 of an inch in this distance.

The lowest barometer at points on either side of the cyclonic area occurred when the center of the storm passed nearest such places and the time of their occurrence coincided with the time that the center of the storm crossed a line passing through such places at right angles to the line along which the center of the storm was advancing at that time.

If, on either side of the storm center, the times of the occurrence of the lowest barometer at two or more stations parallel with a line crossing the line of advance of the storm center are available, the exact direction in which the cyclonic area was advancing at that time can be determined. In this connection see figure 1, which gives the lowest barometer readings and the times of their occurrence in this storm.

WINDS.

Moderate gales occurred at New Orleans and Burrwood, the only regular Weather Bureau stations with self-recording instruments directly in the hurricane proper.

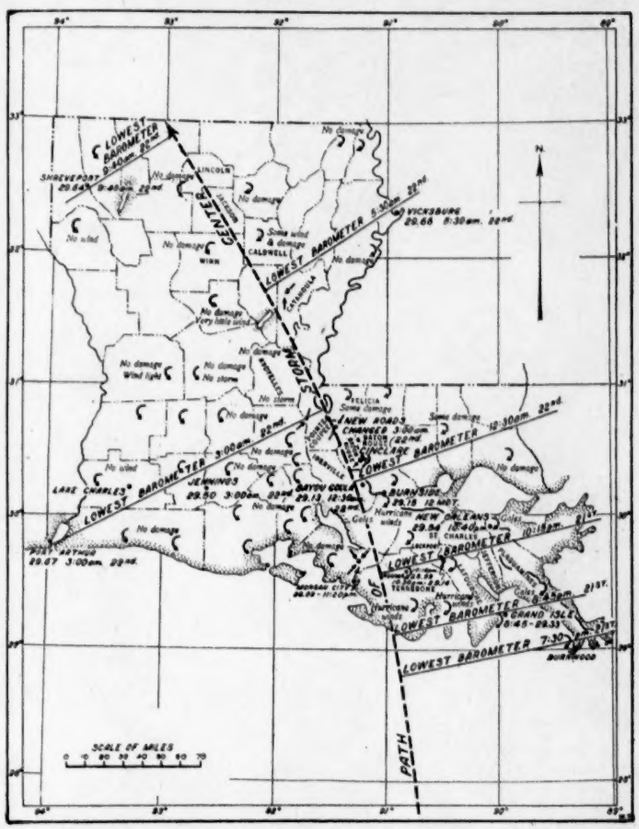

FIG. 1.—Wind changes and path of hurricane. Time of occurrence and lowest barometer in different parts of the cyclonic area, and connecting lines intersecting path of storm at right angles.

Gales occurred to the right of the cyclone as far as Pensacola, Fla., and Mobile, Ala., but the wind velocities at these two places can not be attributed altogether to the tropical storm, as their winds, both in direction and velocity, were controlled more by the anticyclonic area over the East Gulf and Atlantic States than by the cyclonic area over Louisiana.

Hurricane winds occurred in Jefferson, Lafourche, Terrebonne, and St. Charles Parishes and destructive gales occurred in St. John, Ascension, and Iberville Parishes. Reports from cooperative observers cover this storm fully. Extracts from the reports of cooperative observers are given below.

Where the correspondent in a parish reports "No storm" or "No damage" that fact has been stated in the parish on figure 1, and the direction in which the wind shifted as the storm advanced is also shown. This chart furnishes information of special interest. The changes in the wind in the right and left hand segments of the cyclone show the exact path of the hurricane center during its progress for 100 miles after its center reached the coast. No damaging winds occurred to the left of the line along which the center of the storm advanced.

At Morgan City the wind changed from northeast to northwest at 10:30 p. m., then calmed down and shortly afterwards came up light from the southwest. The lowest barometer occurred at 11:30 p. m., during the period in the lull in the wind. This indicates that the center of the storm passed nearly over Morgan City, and that the exact center of the storm passed to the right of that place. No severe winds occurred at Morgan City, but a few miles to the right of that place the wind was of hurricane force.

At New Roads in Point Coupee Parish the wind shifted from northeast to southwest at 3 a. m., which indicates that the center of the storm passed over that place at that time.

North of Iberville Parish, no winds out of the ordinary were reported either to the right or left of the line along which the center advanced until Caldwell and Lincoln Parishes were reached, where the disturbance again showed increasing intensity.

PRECIPITATION.

Conditions were such that no precipitation occurred in the region visited by the storm prior to the morning of the 22d except that caused by the tropical cyclone, and we had excellent opportunity for the study of precipitation in the various parts of the cyclonic area as it moved inland. Light precipitation was reported from the eastern portion of east Texas on the morning of the 21st, but only a trace at most stations; however, 1 inch at Hitchcock and 1.20 at Beaumont were reported. Light precipitation was reported from only a few stations in southern Louisiana on the morning of the 21st, but by 7 p. m. of the 21st the rain area had extended northward to Vicksburg, Miss., and Shreveport, La., and had extended eastward to Apalachicola, Fla., but had not extended northeastward as far as Mobile, Ala., or Pensacola, Fla. By the morning of the 22d the rain area had extended northwestward over northeast Texas and into eastern Oklahoma in front of the direction in which the storm was advancing, while to the eastward of the center precipitation had extended into southwestern Alabama, over southern and central Mississippi, and into southern Arkansas. The precipitation was heaviest on the Mississippi coast about 90 to 135 miles to the right of the center of the storm; here a few stations report 5 to 7 inches. Over southeastern Louisiana and southern Mississippi, to the right of the line over which the center of the storm advanced, 100 to 150 miles inland, the precipitation was generally 2 to 5 inches. In southern Louisiana, to the left of the line over which the center of the storm advanced, the precipitation slightly exceeded 1 inch. Over the interior of Louisiana, after the storm had become extratropical, the rainfall on both sides of the storm ranged generally between 1 and 2 inches, but no station received as much as 2 inches.

Elsewhere the amounts of precipitation were mostly light. The distribution of rainfall in relation to the center of the storm is shown in figure 2.

Lightning was not observed and no thunder was heard during the storm nor immediately after it. Lightning was observed in the south at 10 a. m. September 22, which was after the storm had moved well inland. The observer at Galveston reported a moderate thunder storm from the southeast in the very early morning of the 21st. Moreover, it is a striking fact that neither has lightning been seen nor thunder heard during the actual passage of a tropical storm over this region. The tropical cyclone, it appears, is not attended by frequent vivid lightning and heavy thunder, as is the case with extratropical cyclones occurring at the same season of the year.

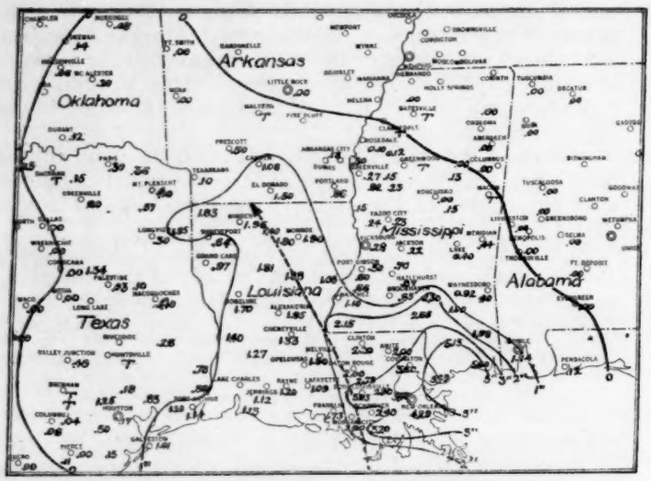

FIG 2.—Distribution of precipitation. At all stations where the names are given the amounts are up to 7 a. m., Sept. 22; at places without names, the amounts are up to 7 p. m. of the 22d, the hour at which they make their measurements.

TIDES.

The tides which occurred followed the predicted tides at Galveston and the interpolated tides based on Galveston for Corpus Christi, Tex., and Burrwood, La., and Fort Morgan, Ala., and those for Port Arthur, Tex., based on Key West, very closely, from noon of September 19 to 2 p. m. on the 20th, when the tides began rising above the predicted tides at both Galveston and Port Arthur, Tex. The rise of the tide above the predicted tide at Corpus Christi did not set in until 6 a. m. of the 21st. The tide at Burrwood, La., showed a slight increase above the predicted tide at 2 p. m. of the 20th, but no material rise above the predicted tide occurred except on the Texas coast up to 12 noon of the 21st, which indicates that the storm was moving toward the Texas coast during the 20th. After noon of the 21st the tide at Galveston showed a tendency to return to the predicted tide, and at Port Arthur and Corpus Christi, Tex., the tide did not rise farther above the predicted tide. The tide at Burrwood and Fort Morgan commenced rising slowly but steadily above the predicted tide about 2 p. m. of the 21st and it continued rising as the storm approached, the storm tide at Burrwood being 1 foot at 7 p. m., 1.8 feet at 8 p. m., and 2 feet at 10 p. m., in excess of the predicted tide. Burrwood was 90 miles to the right of the line over which the center of the storm was advancing. At Grand Isle, La., 60 miles to the right of the line over which the center of the storm was advancing, the storm tide had become so pronounced at 4 p. m. (just two hours after the well-defined rise set in at Burrwood) that the officer in charge at the Coast Guard station at Grand Isle called all the inhabitants on the island into the station, which was constructed for use as a place of refuge in case of a hurricane.

Burrwood is the only available tide-reporting station within 100 miles of the point where the center of the storm moved inland. The storm tide occurred on low tide. If the storm had come in during the morning the tide would have been higher by more than 1 foot. As the storm moved inland over Louisiana, the waves and swells banked a tide of 5 to 6 feet along the Louisiana coast in Lake Borgne and on the coast of Mississippi Sound, which overflowed the tracks of the Louisville & Nashville Railroad. The rise in the tide above the predicted tide on the Texas coast during the afternoon of the 20th and forenoon of the 21st shows that during the 20th, the storm was moving toward that part of the coast. The cessation of the rises in the tide on the Texas coast about noon of the 21st, and the steady rise that commenced on the Louisiana and Mississippi coasts soon after

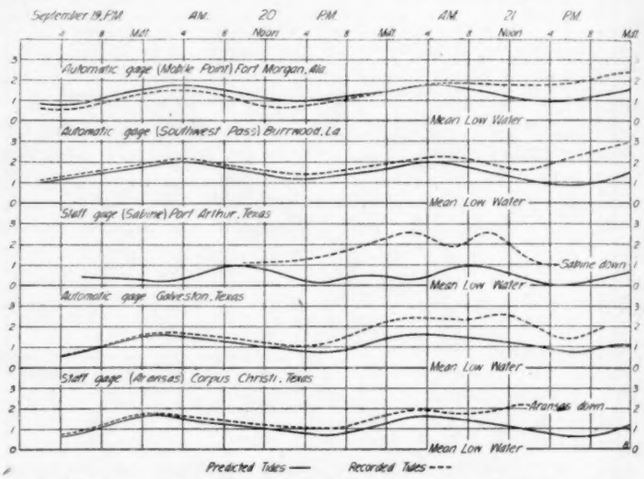

FIG. 3.—Tidegraphs, September, 1920. Predicted tides for Burrwood (Southwest Pass), La.; Fort Morgan (Mobile Point), Ala.; and Corpus Christi (Aransas), Tex., are calculated from the standard port, Galveston; and Port Arthur (Sabine), Tex., from Key West.

noon of the 21st, show that the storm changed its course in about latitude 25° and longitude 90° (the position the storm occupied when Supervising Forecaster Bowie issued his warning at 10 p. m. of the 20th) during the night of the 20th and the early morning of the 21st from the Northwest and took up a course just a little west of north toward Atchafalaya Bay, La. The increased rise in the tide at Burrwood, with the position of the storm as above noted, shows that the swells that came out of the right-hand rear quadrant of this storm and caused the rise in the tide on the east Louisiana coast traveled with a speed of about 30 miles per hour. The center of the storm reached the coast about seven hours after the rise in the tide commenced, and this indicates that the center of the storm advanced during the 21st with an average speed of nearly 15 miles per hour before its center reached the Louisiana coast.

As late as 5 p. m., September 21, the greatest fall in the barometer was on the east Texas and west Louisiana coasts, but at this time and for three hours previous, the only continued rise in the tide above the predicted tides was on the east Louisiana coast and on the Mississippi Sound coast. The barometer continued to fall on the

east Texas coast and in southwest Louisiana until 3 a. m. of the 21st, seven hours after the center of the storm had moved inland, but no additional storm tide occurred on the Texas coast after noon of the 21st, eight hours before the storm moved inland 400 miles to the eastward from Galveston, Tex. The tides during the approach of the storm are shown on figure 3.

PATH AND MOVEMENT OF STORM.

The storm moved inland over the central and east Louisiana and the Mississippi coasts. The center of the cyclonic area advanced northward in Louisiana along a line running close to longitude 91°, and the calm area of the center passed partly over Morgan City, La., and thence northward over the interior into Iberville Parish near Bayou Goula. Records of the lowest barometer and the times of their occurrence during the passage of the storm were made at an exceptionally large number of points in the area traversed by the storm and from these the speed with which the cyclonic area advanced has been determined. Near the center, the lowest barometer at Houma occurred at 10:15 p. m., and at Burnside and Bayou Goula, the lowest occurred at 12 midnight of the 21st and 12:30 a. m. of the 22d, respectively; the distance from Houma to these places is 50 miles, and two hours' time intervened between the time of the lowest barometer at Houma and its occurrence at Burnside and Bayou Goula, which shows the storm advanced with a speed of 25 miles per hour, an unusually rapid movement for a tropical cyclone in this region. New Orleans and Grand Isle, 50 miles apart, are on a line nearly parallel to the line over which the center of the storm advanced. Two hours intervened between the time of the occurrence of the lowest barometer at Grand Isle and its occurrence at New Orleans, which confirms a progressive movement of 25 miles per hour, twice the average speed traveled by tropical storms in this latitude and 10 miles per hour greater than the speed of any of these storms which have come under the writer's observation during the last 30 years. The path along which the center of this storm advanced is definitely located both by the direction in which the winds changed from north to south and also by the lowest barometer readings.

The storm retained hurricane intensity until Ascension and Iberville Parishes were reached. It diminished in intensity with marked rapidity and advanced more slowly on reaching the bluff lands of Baton Rouge and Feliciana Parishes and the heavily timbered regions along the Atchafalaya and lower Red Rivers in Pointe Coupee and Avoyelles Parishes. The winds north of Iberville Parish were not dangerous to any extent either to the right or left of the line over which the center of the storm had been advancing and no well defined changes in the wind by way of east or west to south were noted between Iberville Parish and Caldwell Parish, to the northward. The wind at Cinclare, west Baton Rouge Parish, shifted from north directly to the south; at New Roads, Pointe Coupee Parish, it shifted from north directly to southwest. At Mansfield, Catahoula Parish, the wind blew first from the north then from the south. Strong winds occurred during the forenoon of the 22d, 150 miles to the northward from Pointe Coupee Parish, in the region of Caldwell, Jackson, and Lincoln Parishes, and the storm advanced more rapidly after passing the bluff and timbered regions.

The lowest barometer at Galveston and Port Arthur, Tex., and Lake Charles and Jennings, La., occurred at 3:40 a. m. to 3 a. m., respectively, on the 22d, which is six to eight hours after the center of the storm had moved to the northward of those latitudes. This continued fall in the pressure so far to the west of, and in the rear of, the location of the center of the storm at midnight of the 21st, indicates that the storm, when it lost its intensity on reaching the bluff and timbered lands was crowded to the westward by the eastern high pressure area and then formed a general, but weak low pressure area, extratropical in nature, covering Louisiana with its center over Caldwell and Winn Parishes, as appeared on the weather map at 7 a. m., September 22. The storm at that hour showed a well defined but weak cyclonic circulation over Louisiana; it advanced toward the northwest and was centered at 7 p. m. of the 22d a short distance to the northeast of Fort Smith, Ark.

WARNING SERVICE.

Warnings announcing the development of a tropical disturbance over the western Caribbean Sea were received on the night of September 18, and advisory warnings were received regularly thereafter until the passage of the hurricane inland. These warnings gave the location of the disturbance and its probable direction of movement and were distributed by telegraph to all coast stations and radiographed to ships at sea and published in the daily papers.

The exceptionally rapid progressive movement of the disturbance across the Gulf of Mexico was announced by the Supervising Forecaster on the 20th when he ordered warnings as follows:

WASHINGTON, D. C., *September 20, 1920.*

Hoist northeast storm warnings 10 p. m., New Orleans to Port Lavacca, Tex., and northwest storm warnings Corpus Christi section to Brownsville. Tropical storm apparently centered in latitude 25°, longitude 90°, of considerable intensity and moving northwest. Advise all interests to be on the alert.

BOWIE.

Hurricane warnings were ordered displayed from Morgan City, La., to Corpus Christi, Tex., at 10 a. m. on the 21st and were extended eastward along the Gulf coast to Pensacola. Fla., at 9 p. m. on that date.

An extraordinary distribution of warnings was commenced at once on receipt of the orders to hoist hurricane warnings. A motor boat was chartered and sent from Lake Arthur to Cameron, La., and intermediate points. The warnings were sent to all telephone exchanges in the threatened areas and Mr. C. A. Stair, District Superintendent, instructed the managers to give the warnings the widest possible distribution by telephone.

The telegraph companies instructed their managers to give the warnings the widest possible distribution in the interests of their customers.

Railroad superintendents sent the warnings to their station agents with instructions to advise all interests to take every precaution against high winds and high tides. In New Orleans the police and fire departments were used in advising the public of the approach of the storm.

DAMAGE FROM STORM.

The display of hurricane warnings at Morgan City, La., on the morning of the 21st caused persons living near the Gulf coast and along the bayous in the area covered by the storm warning to move to interior towns.

Storm tides and waves are the agents of greatest destruction in tropical storms and as this storm came in at low tide the damage along the coast was not so great as it would have been if the storm had moved inland in the forenoon.

Damage was confined mainly to railroad, telegraph, and telephone systems, the losses sustained by these interests being estimated at $750,000. The tides and waves washed out the Louisville & Nashville Railroad bridge at Chef Menteur and damaged the roadbed in other places to such an extent that it was about ten days before train service could be resumed. The telephone company reported 2,500 telephones out of commission in New Orleans and a little more than one third of the long distance system was put out of commission. The telegraph service west and north was badly crippled. The telephone and telegraph services were restored promptly. Damage to rice and sugar cane was confined mainly to Terrebonne, Lafourche, Plaquemine, and Jefferson Parishes. The total damage to crops is estimated at about $700,000. Only one death was reported and that as a result of an electric wire which had been broken down by the wind at New Orleans.

The fact that not a sea-going vessel was lost in the storm and only one life is reported lost shows the great value of the warnings and the effectiveness of their distribution.

NOTE.—Full reports of cloud observations, barometer readings, and remarks of cooperative observers can be seen on the original manuscript on file in the Central Office of the Weather Bureau, Washington, D. C.

TROPICAL STORM, SEPT. 29–30, 1920.

By ALEXANDER J. MITCHELL, Meteorologist.

[Weather Bureau, Jacksonville, Fla.]

The existence of the tropical storm of September 29–30, was first announced by the Central Office on September 27. (See pp. 544–545, below.) At the time reports from coast stations were rather indefinite, except that the wind direction may have been an affirmative factor.

Minus pressure changes became more significant on the 28th, and on the 29th they were conclusive as to the future direction of the disturbance. The rainfall increased on the lower coast of the section on the 28th, becoming heavy and general in the west-central portion of the peninsula on the 29th, on which date minus pressure changes were confined to South Atlantic districts and the immediate Gulf coast from Louisiana eastward. The western anticyclone, but feebly felt in the west Gulf States on the 28th, had, by the 29th, increased in magnitude and was rapidly pushing east and south, thus adding celerity to the northeast movement of the disturbance, as was indicated by the forecaster in his early advisory messages regarding the probable course of the storm.

The configuration of the isohyets and the 24-hour rainfall show the approximate path of the storm to have been from near Cedar Keys on the Gulf coast, which it approached during the night of the 29–30th, thence northeast to the Atlantic seaboard. The 24-hour rainfall along the path of the storm ranged from 5 inches at Cedar Keys, Levy County, to 8 inches at Lake City, Columbia County. Local observers reported "high winds," "storm," or "gales."

The storm was very severe when deep into the Gulf, as indicated by reports from masters of vessels, but it was probably losing energy as it approached the coast, as the minimum central pressure was not below 29.47 inches at any Florida station. Gales occurred, however, from Key West northward during the night of the 29th and early on the 30th. And considerable damage was done along the west coast from about Fort Myers northward to St. Marks. High tides, salt spray, and high winds inundated low lands on the immediate coast, and heavy rains flooded fields more inland, where truck and fruit suffered to a considerable extent. As the result of a prostrated wire one person was killed at St. Petersburg. A yacht was sunk at Fort Myers, and a number of vessels were wrecked or dismantled in the Gulf, among which was the American steamer *Speedwell*, en route British Honduras to New Orleans.

In view of the existence of the strong anticyclone which was rather exceptional for these low latitudes so early in the season, resulting in the breaking of minimum temperature records, is it altogether unorthodox to suspect an interdependence between the two phenomena? At least a relationship more than casual or incidental? Did the tropical storm, as reflected in the wide area over which a great displacement took place, accentuate the upbuilding of the "high"? Its counterpart, the cold wave, is not altogether the result of translation from high to low latitudes, but it arises, in a great measure, probably, as the result of outward radiation from the barren regions, of higher latitudes. Most of the great anticyclones, as they sweep south and east, incidentally develop LOWS which, as well developed entities, frequently play a vital part in the ultimate effects of cold waves.

TYPHOON IN PHILIPPINES.

By JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I., September, 1920.]

On the evening of August 31 a small typhoon struck Manila, the worst experienced in the city since September, 1905. It had formed almost unexpectedly in the China Sea, west of the southern part of Luzon, and moved ENE. across the Provinces of Bataan, Rizal, Bulacan and the narrow strip of the northern part of Tayabas, a track altogether abnormal and never before observed in the neighborhood of Manila. Considerable damage was done to the four provinces just mentioned as well as to Manila, particularly to the shipping, Corregidor and to the northern part of Cavite Province. The center passed between 7 and 8 p. m. a few miles north of the observatory where a gale blew for two to three hours backing very quickly from SE. to S., SW., and WNW.; relative calm was observed for about 15 minutes. The barographic record obtained on this occasion shows how small the typhoon was: it might be well called a miniature of a typhoon. In the early morning of September 1 the cyclonic center could still be noticed over the Pacific ENE. of Manila near Polillo Island; but it soon disappeared probably absorbed or swallowed up, we may say, by a big typhoon which was sweeping the Pacific from Guam to Formosa.

This big typhoon had passed near to the north of Guam on August 28, the barometric reading being at 2 p. m. as low as 742.9 mm. (29.248 inches), gravity correction applied, and a gale blowing for several hours from the north and west quadrants. The typhoon moved practically WNW. and struck Formosa on September 4. When the center was in Meiacoshima on September 3, it caused such

a considerable falling of the barometer, that the meteorological station of Ishigakishima reported at noon a barometric reading as low as 703 mm. (27.677 inches). All the telegraphic communications of Formosa were cut off, and it is believed that much damage was done by the typhoon throughout the island.

Another well-developed and severe typhoon swept the Pacific between the Ladrone Islands and the Loochoos from September 22 until the end of the month. Its center was clearly situated west of Guam on the afternoon of September 22, and passed north of the S. S. *Newport News* on her way from Manila to Guam, a gale being reported by her from the southwest to the southeast quadrants and a moderate falling of the barometer. The track of this typhoon is typical of those which recurve north and northeast far from the Philippines and move toward Japan, where the storm is supposed to be raging at the time these lines are being written (Sept. 30).

CLIMATOLOGICAL FACTORS GOVERNING THE SELECTION OF AIR ROUTES AND FLYING FIELDS.

By C. LE ROY MEISINGER.

[Weather Bureau, Washington, D. C., Oct. 4, 1920.]

SYNOPSIS.

Although the current values of weather conditions usually differ radically from the averages, they are important nevertheless in the selection of aerial routes and flying fields. For the preliminary selection of aerial routes, the normal values of the following elements are the most important:

1. Speed and direction of the wind.
2. Frequency of low clouds and fog.
3. Frequency and intensity of thunderstorms.
4. Vertical temperature distribution and its diurnal changes.

For the selection of flying fields there are needed, in addition to the above values, the normal values of precipitation.

INTRODUCTION.

There is, it seems, a vagueness in the opinions of many people regarding the value of meteorology in the selection of air routes. One reads of "pathfinding" and of "charting" flights by which it is implied that a single journey or, at most, several journeys over a proposed course will afford sufficient data to designate that route as satisfactory or unsatisfactory for continued use. Such reasoning is unsound. It is obvious that the aerial medium is possessed of such a host of variable attributes, that the conditions which one finds to-day may not occur again in precisely the same combination for months or even years. Of what profit shall it be to measure the temperature, humidity, and other elements, in a single flight, unless it be that these data are to be used in the discussion of the flight itself, relative to the performance of the motor or instrumental equipment, the physiological reaction of the travelers, or in one or more of the several other problems that may take the form of special tests? If such observations are to be made, they should be made over a wide area, by numerous craft, and as nearly simultaneously as possible. The ocean of air is far from being a fixed thing. Perhaps the likening of the atmosphere to the aqueous ocean is a figure of speech which has been somewhat overdone, and has resulted in the popular conception of aerial currents as fixed as the Gulf Stream or the Japan Current. It is also possible that the pioneer work of Rotch and Palmer, *Charts of the Atmosphere for Aeronauts and Aviators*, which appeared in 1911, did not lay sufficient emphasis upon the pitfalls of too great reliance in averages. Our atmosphere is not made up of great permanent streams and currents, and even our conception of prevailing westerly winds aloft is sometimes shocked by the spectacle of cirrus clouds moving from the north, east, or south. Therefore, efforts to lay down definite airways without reference to the fundamental conditions which really determine desirable routes can not prevent themselves being relegated to positions of slight importance. It would be unfair to assert that any carefully made scientific observation is of no value; but it is obvious that, in such matters as the selection of air routes, other factors than such observations must be considered before one can legitimately make generalizations upon so subtle a medium as the atmosphere.

THE SELECTION OF ROUTES.

It is self-evident that the point of departure and the destination must determine the general direction of flight. But it is by no means axiomatic that the air route shall follow a straight line between these two points. Irregularities of the terrain, its physical characteristics, and the weather along the route must, in the last analysis, determine the course of the aviator, if he is to cover the distance with the greatest economy of time and fuel. In brief, it is the geography and the climate of the region between two stations which must determine the approximate route, but the weather at the time of flight must determine the details of the aviator's course.[1]

While the fact is recognized that a single condition may not be representative of the weather over a given route, and also that mean conditions over the same route may differ greatly from the conditions of any particular day, it is believed, nevertheless, that the best basis for laying out a preliminary route between two points lies in the mean values of certain climatological and aerological factors.

Wind.—Perhaps the most important of all the weather elements to the aviator is the wind. It is necessary in commercial aviation to take advantage of any conditions which will aid in economy of time or fuel or will be conducive to greater safety. If, then, the "pathfinder" is to live up to his name, his first concern must be to determine the speed and direction of the prevailing winds over the proposed route. These winds should be determined, not at the surface alone, but to as great altitudes in the free-air as possible. Moreover, it is very likely that he will discover that certain elevations will, in the long run, be more favorable for flying in one direction, and that other levels will be more favorable for the return journey. Rouch and Gain[2] have shown how important such wind studies are in regard to flying in northern Africa. The journey from Oran to Tunis, they find, should be made at an altitude of about 2,000 meters, because at this elevation a strong westerly wind prevails. The return journey, in the long run, will be made most profitably at an altitude less than half as great, because the westerly wind at that elevation is greatly diminished in force. Such prevailing winds should be determined from as long records as are available and should be worked out for small time units; seasonal

[1] A later article will show how current conditions may modify an air route with a saving in time and fuel.

[2] Les cartes des vents à l'usage des aéronautes. *Revue générale des Sciences*, Mar. 30, 1919, pp. 168-171.

averages would be valuable, but monthly means would undoubtedly be better. Not less valuable in this connection are the means of diurnal wind changes, both in speed and direction. In fact, each additional factor brings the conditions nearer to those which the aviator is likely to encounter in flight.

Digressions from the great circle[3] path between two points would be most helpful in cases of high winds and relatively slow-moving craft. Thus, a high-powered airplane flying at 110 miles per hour in a gentle wind would gain little, if any, by departing from the great circle. But a dirigible, on the other hand, moving at 60 miles per hour might find it very much to its advantage to follow the general direction of wind flow if the wind speeds were quite high and if the curvature of the wind path were such as eventually to bring it near its destination. Thus, the gain to be made by departing from the great circle becomes smaller and smaller as the ratio of craft speed to wind speed becomes greater.

Cloudiness and fog.—The influence of the lower clouds and fog upon flying is very great. As a rule, it is essential to retain sight of the earth. When there are low clouds and fog, however, to keep in sight of the earth is obviously a hazardous proposition. The disadvantages of low flying when there is a cloud layer quite close to the ground have been set forth by Prof. B. Melville Jones,[4] as follows: 1. Strain to the pilot, owing to constant bumpiness, poor visibility, and proximity to the earth. 2. Danger of collision, occasioned by poor horizontal visibility. 3. Discomfort to pilot and passengers, since flying above clouds is exhilarating. 4. Choice of altitudes is limited, and therefore it is difficult to select advantageous flying levels. 5. Annoyance to people on the ground. 6. Danger in case of forced landings.

While Prof. Jones inclines to the view that overcloud flying has advantages over undercloud flying when the clouds are low, he does not hesitate to point out the danger and discomfort occasioned by having to ascend to great heights to clear clouds; moreover, it not infrequently happens that the cloud layer is thick, or that there are several layers. The danger of flying in clouds is great, not only because of the possibility of loss of sense of balance by the pilot, but because the clouds may reach the ground without his knowledge, thus making a crash likely when attempting to land or descend to lower levels.[5] There is also the danger of being unable to find the landing field at the end of the flight and the difficulty of navigating without visible points on the earth. Whatever may be the advantages of overcloud flying, there is no escaping the fact that low clouds are a menace to the airman.

It is therefore necessary in the laying out of proposed aerial routes to consider carefully the frequency of low clouds and fog. Bodies of water, such as lakes, rivers, and the ocean, as well as cities and deserts, often contribute to the formation of fog and the production of low visibility.

Thunderstorms.—To the pilot of heavier-than-air craft no less than to the pilot of lighter-than-air craft, the thunderstorm is a formidable enemy and one to be studiously avoided. The few who have ever penetrated the interior of a thundercloud have suffered experiences which they would not care to repeat, if, indeed, they have come through alive. Dr. Charles F. Brooks has discussed several instances in which aviators have described their experiences in or near thunderstorms.[6]

Lighter-than-air craft are forced into the uncomfortable situation of having to land, or attempt to fly above, or around, the thundercloud, any or all of which may be extremely difficult. In the case of a dirigible balloon, it may be possible to fly around the storm as an airplane might do, and thus succeed in avoiding it. The alternative of landing in the face of the oncoming storm with its squall wind is not desirable because of the difficulty of handling the balloon on the ground. To attempt to fly over a towering thunderstorm may be entirely out of the question owing to the excessive altitude which would have to be attained, for great altitude necessitates unpleasant physiological effects and the loss of gas (through expansion) and ballast.

It is true that usually the thunderstorm is essentially a local phenomenon, which may attend the passage of the windshift line in a LOW or may be formed locally by strong convection. Thus, the chances of encountering thunderstorms during a given trip are very much dependent upon current general conditions. But the frequency of occurrence of thunderstorms along a given route is a thing that it is vitally important to know. For one may discover that in certain months in a given region the thunderstorm frequency is so great as really to endanger the maintenance of schedules. An aircraft corporation may discover by such statistics that their craft will be placed in great danger by maintaining routes through regions of great thunderstorm frequency. The wisest course in those cases might be to modify the schedule during those times, to select new routes, or to discontinue service in that region temporarily. Again, this knowledge can give some clue to the possibility of profitably modifying the administrative activities of the corporation, such as shifting the personnel of flying fields, distributing equipment, extra parts and supplies. All of these factors will have their reflection in direct financial returns. A blind indifference to the statistics of climate over air routes is, therefore, a narrow business policy, and that corporation which manifests this indifference is the one which, no matter how skilled its pilots, will find its dividends dwindling because of loss of equipment through accidents and consequent loss of popularity with the public.

Temperature.—The knowledge of mean temperatures over routes is perhaps the least important of the weather factors. It is true that temperature has a profound influence upon the maintenance of schedules in extreme weather. But with the improvement of aircraft engines so that they function at extremely low temperatures, and with the electrical heating of the cabins of passenger-carrying planes and dirigibles, the influence of the temperature factor is appreciably lessened. Information regarding average vertical distribution of temperature and of the diurnal change of this distribution is helpful. Unfortunately such data are somewhat limited, but the Aerological Division of the Weather

[3] It is so customary to think of the earth's surface as it appears on a flat map that the fact often is lost sight of that the shortest distance between two points on a spherical surface is the arc of the great circle upon which the two points are located. This applies chiefly to long distances and is used by mariners; but it also applies in the case of long aerial routes.

[4] Flying over clouds in relation to commercial aeronautics, *Aeronautical Journal*, May, 1920, pp. 220-249. Abstract in *Aeronautics*, Mar. 18, 1920, pp. 240-243; also in this REVIEW, pp. 528-529.

[5] The writer had such an experience in a free balloon. Having ascended into a rather low layer of clouds and having lost all sense of direction, the party was surprised to discover several hours later that the trail rope of the balloon was dragging on the ground. The low clouds had actually reached the surface. For full account, see "A free balloon flight in the northeast quadrant of an intense cyclone," MONTHLY WEATHER REVIEW, April, 1919. 47: 233-235.

[6] The effect of wind and other weather conditions on the flight of airplanes. MONTHLY WEATHER REVIEW, August, 1919, pp. 523-532. See also Meisinger, C. LeRoy: A balloon race from Fort Omaha through thunderstorms, idem., pp. 533-534.

Bureau is conducting a study of a great number of kite flights which will probably supply to a large degree this need. The knowledge of mean vertical temperature distribution is not as important in the preliminary laying out of air routes as in the discussion of the current data supplied to the aviator just before he ascends.

Humidity and precipitation.—These elements are not of great importance at the outset, and they are so interwoven that their value depends chiefly upon the interpretative ability of the consulting meteorologist at the flying field.

THE SELECTION OF FLYING FIELDS.

The problem confronting the person whose duty it is to select a flying field is not an easy one; or, at least, it is one that can not be rightly solved by a mere consideration of the civil or military requirements. To-day, with the multitude of flying routes being established, it sooner or later becomes the problem of the commercial clubs or chambers of commerce in most large cities to determine a landing field in the immediate vicinity. These fields have a great commercial value to the city. It is not denied that many of the local aspects, such as the availability of property, accessibility, etc., each peculiar to a given locality, rightfully have a foremost place in the consideration. But the meteorological aspect can not be neglected, for it is conceivable that, in spite of a hundred desirable features of a landing field, there may be certain characteristics which, from a meteorological standpoint, will render it utterly unfit for the purpose. Again assuming the climatic features to be favorable, the field itself must be so laid out that it will serve most efficiently. That is to say, for instance, that the long axis of the field, if it be small and rectangular as many are, should lie in the direction of the prevailing wind at the place, because it is necessary that planes land heading into the wind and that they also rise in a headwind. The buildings should be so oriented and distributed as to interfere the least with landing or rising planes, and where the eddies and gusts they cause will not interfere with craft flying low over the field.

A very striking example of the consequences of neglecting the meteorological aspects is given by Rouch.[7] During the war, the British desired to establish a training field for aviators for bombing instruction, and a commission was appointed for the purpose of determining the location. The shore of Loch Doon, in Ayrshire, was chosen. After the work of establishing the field was well along, the hangars were being built, a railroad was contracted for, and other expensive arrangements had been made, it was discovered that the neighboring hills gave rise to eddies and squalls which absolutely prevented safe flying at that place. The field was abandoned with a loss to the Government of upwards of $2,000,000. In conclusion, Rouch says, "The installation of some instruments and the consultation of some tables of figures would have permitted 12 million francs to be saved. In that circumstance, sadly writes the *Times* (London), the authorities did not perform their duty." It is unnecessary to emphasize the import of this example.

The Air Service recognizes the tremendous importance of the climatological considerations in the selection of flying fields.[8] To quote from the circular which discusses this question:

> The number of flying days to be expected in a year or in any month may be fairly well determined from a study of the climatic factors. * * * It is also possible from this study to arrive at a fairly definite conclusion as to the accessibility of the field by aerial routes for different types of aircraft. In other words, one may determine the sort of aerial harbor, ease of entrance, exit, and other things considered which aircraft would find at a given field. * * * The prevailing wind and storm directions largely determine the layout of a field. The number of days to be expected when the wind speed is too high for the operation of aircraft may be closely determined. Also the number of days with excessive precipitation, with fog or storm to be expected, may be closely approximated.

The weather factors to be taken into consideration are quite the same as those which may determine aerial routes. Precipitation comes in for greater consideration in the case of landing fields. A plane can not land or take-off readily on a muddy field, and a snow cover demands the greatest attention.[9] As the Air Service circular points out, topography and wind are inseparably bound together in relation to aeronautics. The effect of wind blowing over a rough terrain is to produce rough air in which to fly. Landing fields in a hilly region are especially apt to be dangerous; and the proximity of trees and high buildings is likely to cause roughness extending to a height three or four times as great as the object. This is dangerous to a plane slowing down for a landing or for slow-flying planes.

CONCLUSION.

An effort has been made to present the vital importance of meteorological studies in connection with the establishment of aerial routes and the layout of flying fields. The argument does not pretend to overstress the use of averages in connection with such work, but it does attempt to emphasize their importance in the preliminary work. Meteorology is the mainstay of aviation regardless of the confidence of the aviator in his motor and its ability to carry him safely over all obstacles. The dirigible has inspired us with a confidence in its future as a commercial transport; the aerial mail has definitely stamped the airplane as a reliable means of rapid transportation of mail, baggage, and passengers. Great aerial corporations are being organized. They are commercial enterprises, highly capitalized, and founded for the purpose of paying dividends to their stockholders. Dividends depend upon the skillful management of the assets of the company, the reduction of the expense of maintenance, the extension of routes into the most profitable places, the acquisition of the public confidence. Every accident is detrimental to the cause of aviation, not alone because of the direct financial loss, but because it weakens the public confidence. The record of the Aerial Mail Service shows that the weather is responsible for the greatest number of accidents and forced landings.[10] Many of these could be avoided by giving the weather its due consideration. Here is one of the places where the consulting meteorologist is urgently needed.

[7] Préparation météorologique des voyages aériens. Paris, 1920, pp. 53–54.

[8] Meteorology and Aeronautics. *Air Service Information Circular*, May 12, 1920, vol. 1, No. 77.

[9] A note in *Aeronautics*, Mar. 18, 1920, p. 230, tells of the addition of ski attachments to the plane where landings have to be made on snow. One of the great difficulties of landing on snow, as on water, is to tell how high the airplane is above the surface, for, with a perfectly smooth snow cover, it is difficult to judge distance; and even to know when the skis are actually in contact with the snow.

[10] Effect of weather on the Aerial Mail Service. MONTHLY WEATHER REVIEW, June, 1920, pp. 335–336.

METEOROLOGY AND AERONAUTICS.

The *"Air Service Information Circular (Heavier-than-air)"* published by the Director of the Air Service at Washington, under date of May 12, 1920, contains an interesting statement of the kind of meteorological information that is required in the location, layout and maintainance of heavier-than-air flying fields. The meteorologist who is not in personal touch with the practical problems confronting the aviator is prone to neglect or to fail to recognize certain climatological or meteorological aspects of the aviator's work.

The circular is evidently intended to be of service to the aviator or engineer confronted with the task of selecting landing fields, or to the army meteorologist whose duty it is to supply the current meteorological data after the field is in operation. The methods employed by the Meteorological Section of the Signal Corps in France are presented, together with some of the charts which were found useful during the war, namely, the light chart, showing daylight, twilight, moonlight, and starlight, and the chart of magnetic declination. At the end is a short bibliography on aerology and meterology.

As a guide to these men in the service whose work falls along this line, this circular may serve a useful purpose. But to the meteorologist this concise statement from the flyer as to what he wishes to know about meteorology should serve as a timely guide as to the direction along which he should proceed. In France, J. Rouch has prepared a booklet entitled *"Préparation Météorologique des Voyages Aerienes."* There is a field for a similar but more comprehensive work in the United States.—*C. L. M.*

FLYING OVER CLOUDS IN RELATION TO COMMERCIAL AERONAUTICS.[1]

By Prof. B. MELVILLE JONES.

[Abstract and excerpts from a brief of this paper in *Aeronautics*, Mar. 18, 1920, pp 240-243.]

The problems confronting the aviator on a long distance flight, when there is a heavy cloud layer quite close to the ground, are manifold. The author inclines toward the view that flying above the clouds has many advantages over flying below clouds, and this view was also held to a greater or less degree by those who participated in the discussion. The difficulties of undercloud flying as enumerated by the author are:

"1. Strain to pilot. [Poor visibility, bumpiness, proximity to earth.]

"2. Danger of collision. [A growing problem, accentuated by poor horizontal visibility.]

"3. Discomfort to passengers and pilots. [Flying above clouds exhilarating; below is depressing.]

"4. Loss of power to use favorable winds. [Choice of altitudes limited.]

"5. Annoyance to people on ground. [As routes become definitely established the noise of high-powered engines would be annoying.]

"6. Danger in forced landings." [One may have a better idea of the nature of the land when flying low, but this would be offset by two advantages from flying above clouds, namely, time to remedy slight mechanical troubles in the air without completing the landing, and, if the pilot were familiar with surface wind direction, opportunity to turn aeroplane so as to land against the wind.]

The difficulties of flying above clouds are also enumerated:

"1. Difficulty of actual in-cloud flying. [Loss of sense of balance by pilot is now being overcome by new instruments.]

"2. Danger that the clouds might come to the ground whilst the aeroplane was in or above them.

"3. Difficulty of navigation. [Must be carried out by dead reckoning, astronomical observation, observation of kite balloons or other guide marks, or wireless.]

"4. Difficulty of finding aerodrome at end of flight.

"5. Danger of collision in clouds.

"6. Possibility of having to reach great heights to clear clouds. [Uncomfortable temperatures and physiological effects.]

"7. Danger from storm clouds."

While this paper discussed the entire problem from the standpoint of commercial aeronautics, and the mobilization of resources and organization to assist in commercial aviation, it is important to note that the paper was occasioned purely by meteorological phenomena. Also, of the 13 dangers enumerated under the heads of undercloud and overcloud flying, seven are directly the result of meteorological conditions, while the remaining five are physiological and mechanical. This emphasizes the fact that the aviator is more dependent upon his understanding of meteorological phenomena than upon all other factors combined, if he will fly with the greatest safety and comfort.

The paper was followed by a discussion[2] in which some of the foremost British aviation authorities participated. Among other points brought out by these men there were several regarding the meteorological organization which will permit of greater safety in flying. One of the points of discussion was how to have a continuous record of wind speed above the clouds. Maj. Dobson said that an instrument for use on a kite balloon had been developed which might give some assistance in this direction, and that a modification of it was desirable which would permit of the recording devices registering at the ground continuously. This would do away with the necessity of hauling the balloon down.

Mr. J. R. Pannell brought out an important point concerning the use of altimeters on long flights. While the pilot is in the air, the barometric pressure may change, with the consequence that his altimeter reading, which was last set before he ascended, might be as much as 300 feet in error. If he is traveling over land whose elevation is variable, his altimeter does not indicate height above the surface, but height above the starting point. To correct this difficulty, changes of surface barometric pressure should be given to the plane by wireless, thus allowing the aviator to make the necessary correction. If there were a means of independently knowing the height, a record of barometric change could be made on the craft. This would be of great advantage to a dirigible on a cruise of several days.

The author summarizes the discussion as follows:

"1. That the power to fly in safety over clouds would be of great value to the commercial value of aviation.

"2. That routine flying over clouds can not be undertaken safely with the facilities at present available to the commercial world.

"3. That probably it could be made safe with a suitable organization of ground stations and meteorology and provided that reliable instruments were more generally available * * *."

[1] Paper read before the Royal Aeronautical Society, March 3, 1920; published in full in Aeronautical Journal, May, 1920, pp. 220-249.

[2] Published in *Aero. Journ.*, loc. cit., pp. 238-247.

The author strongly urged the development of new methods and instruments, in order that commercial aviation in England be made practicable. The island location, with the general unfavorable weather, especially during the winter months, has placed England in a rather disadvantageous position in commercial flying and, for that reason, there should be no cessation of activities in improving the methods and instruments used.—*C. L. M.*

THE EFFECT OF BAROMETRIC PRESSURE UPON ALTIMETER READINGS.

In discussing Prof. B. Melville Jones's paper on "Flying over clouds in relation to commercial aeronautics,"[1] Mr. J. R. Pannell brought up the question of the effect upon aircraft altimeter readings of changes in barometric pressure while the craft is in flight. This is especially important in relation to flying on cloudy or foggy days, or days with low visibility. The point seems worthy of emphasis.

A free balloon is, as its name implies, a balloon which rides freely in the air without means of propulsion or steering. It is interesting to note that, for the balloonist maintaining a nearly constant moderate elevation, the question of erroneous altimeter readings caused by difference of barometric pressure between his point of departure and destination, does not arise. It is a well-known fact that the so-called gradient winds blow in a direction parallel to the isobars at levels above those influenced by the friction of the earth's surface. If a balloon rises into such a current its course must also lie along some isobar. Of course, this is not strictly true when the balloon has flown so low that the surface friction has interfered with the wind direction, nor so high that the isobars are greatly different from those at the surface. This implies a range of about 2,000 feet and sometimes more (1,500 feet to 3,500 feet) in which the balloonist may fly without danger of erroneous altimeter readings. This is a point, to which, it is believed, free balloonists have not given much attention.

But, with dirigible balloons and airplanes, this relation does not obtain, for these craft can be steered quite independently in any direction, so that they may take off in one type of pressure formation and land in another. In such cases, it is of vital importance to consider the changes which may have taken place during the flight at the destination and at points along the route. For example, let us consider an airplane flying from New York to Chicago. Suppose the pressure at New York is 30.40 inches at the time of departure and that at Chicago is 30 inches at time of landing (such gradients are not uncommon). The New York field is about 600 feet lower than that at Chicago. If then, with the barometer at 30.40 inches in New York, the aviator sets his altimeter at 0, what will it read when he lands in Chicago? If he thinks only of the elevation of the land, he may assume that the answer would be 600 feet. But if he also considers the possible effect of changing pressure, he will discover that on a summer day, with a temperature of 75° F., a difference of 0.40 inch in the barometer is equivalent to a height of about 380 feet. Hence, instead of his altimeter reading 600 feet when he lands, it will read 980 feet.

The airplanes arriving at Chicago from the east fly across the lower end of Lake Michigan and are for about 20 miles above the lake. If there is a sheet of stratus cloud over the whole region and the aviator, aware that he is in the vicinity of Chicago, decides to descend through this sheet in order to locate himself, forgetting that he should allow for lower barometric pressure at Chicago, he may be unpleasantly surprised to find the waves of Lake Michigan facing him about 400 feet above the altitude he expected, and it may be too late to save himself from a dip in the lake. If he is over land, a crash may result.

Thus when a plane or dirigible is flying for long distances over land it is worth while for the pilot to form some opinion as to the possible changes in barometric pressure along his route and at his destination during the time he is in flight. This will enable him to make corrections for his altimeter readings which will be approximately correct, and certainly will keep him from experiencing such surprises as that mentioned above. The experience of Lieut. Edward V. Wales, who lost his life in the transcontinental air race in 1919 by crashing into a Wyoming mountain in a snowstorm, is typical of accidents which may result.

After all, the quantity measured by the altimeter is not altitude but pressure. Errors as great as 500 feet are easily conceivable on long flights, and when the flight is over a rough terrain with low clouds, it is a factor which can not be neglected.—*C. Le Roy Meisinger.*

[1] Abstract in this REVIEW, pp. 528-529.

METEOROLOGICAL ASPECTS OF THE RECRUITING TRIP OF THE NC-4.

By Lieut. J. B. ANDERSON.

[Pensacola, Fla., Sept. 7, 1920.]

SYNOPSIS.

The Navy Department, during the months September to January, 1919–20, detailed the naval seaplane *NC–4* to make a recruiting trip along the Atlantic coast from Maine to Florida, thence westward to New Orleans, up the Mississippi and Ohio Rivers to Cincinnati and return, ending the flight at Pensacola. The meteorological officer based his forecasts upon the daily weather map combined with the local conditions, and frequently consulted with Weather Bureau officials along the route. Much of the trip was made in unfavorable or stormy weather. Interesting experiments were made with the wireless apparatus concerning the static electricity before a rain, and in determining the direction of thunderstorms. The air was found to be steadier during the inland journey up the rivers than along the coast. The final flight extended to Rockaway Beach, N. Y., contrary to the original plan, and the flight was made in extremely rough weather.—C. L. M.

In describing the meteorological work on the recent recruiting trip of the *NC–4*, it is necessary to explain the nature of the trip so that the reader may understand the conditions under which the work was done, the variety of conditions met, and the necessity of keeping on the schedule.

During the summer of 1919 the Navy Department decided that during the recruiting campaign of the coming fall the *NC–4*, with as many of the crew which had piloted it across the Atlantic in its memorable flight as possible would probably be the best advertising agency at its command. A trip was planned starting from the United States naval air station, Rockaway Beach, N. Y., early in September. The plan was to fly to Portland, Me., then south, stopping at all of the larger cities, to Miami, Fla., thence to Pensacola, Fla., for a day or two, and then up the Mississippi and Ohio Rivers to Cincinnati, Ohio. This last leg was to be made in two long flights. After visiting the Ohio city for three days, the journey south was to start, stopping at all the principal cities, to New Orleans, La., fly across

to Galveston, Tex., back to Mobile, Ala., and then to Pensacola, where the flight was to end. The schedule allowed exactly three months for the complete trip. At each city a stop of from one to four days was to be made to allow for recruiting rallies and other publicity meetings.

Starting early in September, the weather to be expected along the route includes almost all varieties: The Atlantic coast may expect thunderstorms during September and early October; September and October carry with them the possibility of hurricanes; the cyclonic storms increase in intensity during October and November so that strong winds and widespread precipitation may be expected; the latter part of November and December in the Ohio and upper Mississippi Valleys often bring freezing temperatures (endangering the radiators and engine jackets); fogs and even snowstorms, with their extremely poor visibility, are a possibility. At various points along the route it was planned to fly over stretches of land, for in some instances (the Florida Peninsula, for example) it would save hundreds of miles and many hours of flight, hence the forecasting of low clouds became necessary.

The Aerological Service of the Navy recognizes that the weather map is our most dependable source of information in forecasting general conditions for 12 to 36 hours in advance. By its use the general nature of the weather to be expected the next day can be told with fair accuracy. But at an air station this is not sufficient, as flying must continue to the last moment before a storm and the planes must be ready to start the instant the conditions become safe. For this reason the naval aerological officers study the sky and clouds with great care. They become acquainted with all the possible local conditions so that, even though the map shows the station to be under the influence of an active depression and it is certain that strong winds, thunder squalls, rains, etc., are to be expected, the planes and airships may spend as much time in the air as possible. It was recognized that on this trip of the *NC–4* all methods of forecasting available would have to be used—the longer the trip the more important the general conditions shown on the map, and the shorter the trip the more important the reading of the skies. In cases where long flights over land were to be made the information contained on the map was considered the most trustworthy. A few times methods were resorted to which, in the art of forecasting, may seem crude. However, in each instance conditions demanded action, since only the most disagreeable or dangerous weather was allowed to break the schedule and everything which could help even a little was used. One such instance will be described.

With this schedule in mind the central aerological office of the Navy in Washington considered the conditions confronting the meteorological officer assigned to the flotilla for this trip. It was found that most of the cities to be visited had Weather Bureau stations where it would be possible to obtain either the morning weather map or the synoptic reports. After a consultation with the Chief of the Weather Bureau and the Washington district forecasters a circular letter was sent to all local stations to be visited, informing them of the coming of the *NC–4* and instructing the official in charge to render all aid possible. When visiting cities where there were no Weather Bureau stations, the morning and evening synoptic reports were to be received from some near-by city. Besides this, the "Daily forecasts for aviators" were to be received from the district forecasters at Washington.

It may be said at this point that at all cities and at all times the representatives of the Weather Bureau stations rendered the greatest assistance to the flight, often making special trips to their offices at night to obtain information. They were most generous with their advice and counsel, and most of the forecasts made on the *NC–4* were issued after a consultation with the local forecaster.

The U. S. S. *Isabel* was assigned the duty of "Mother ship" for the *NC–4*, hence it was thought wise to carry a theodolite, pilot balloons, and hydrogen on her so that upper-air soundings could be made. Had this plan worked out it might have proved quite valuable although ordinarily the flights were made at about 1,000 feet. However, the *Isabel* was frequently docked in sheltered places and near buildings which would not have allowed successful soundings. A more serious fault, however, was the fact that on the long flights, 4 hours or more, where a knowledge of the upper winds would be of extreme importance, she was compelled to leave 6 to 18 hours in advance of the *NC–4*, and readings that far in advance were not considered worth while. Of course it was not possible to leave the equipment behind for a sounding just prior to the beginning of the flight. Several times the *NC–4* passed the *Isabel* at sea. In such instances soundings at that time would have been a great help and could have been sent by radio, had there been a theodolite available which could have been used on a ship moving over a rough sea.

Owing to the fact that the beginning of the trip had to be postponed from the beginning of September until the 22d, it became more imperative than ever that the flights should take place on the scheduled day because of advancing winter. One important change was made, namely the extension of the trip to Rockaway Beach, N.Y., after changing engines at Pensacola on December 22.

Owing to the crowded condition of the plane (few flights were made with less than 12 aboard), the meteorological officer was usually unable to take observations during the flights and, as a consequence, no doubt, many interesting phenomena were missed. However, several conditions met during the trip, which proved interesting as well as troublesome, will be mentioned.

During the latter part of September the weather along the North Atlantic coast was typical for that season, while at New Haven, Conn., a trough of low pressure covered the southern and central Mississippi and Ohio Valleys and moved slowly to the northeast. The date for flying to Philadelphia found rain and heavy mist at New Haven, extending south beyond Atlantic City, giving a visibility during the morning of less than half mile. It was forecast from the morning map that the weather would clear during the afternoon, so the crew stood by awaiting the first chance to take off. By 3 p. m. the rain had stopped, but the mist continued and showed little signs of clearing, although at times the visibility increased to over a mile. As the flight was necessary, if safe, the aerological office at Rockaway Beach was called by long distance and the chief petty officer in charge reported that although the visibility was still quite poor to the east the rain had stopped and the clouds in the west appeared to be breaking. Believing this to be the end of the bad weather and knowing that the flight was toward better weather the *NC–4* took off about 4 p. m., and within about half an hour ran into clear weather at an altitude of 1,000 feet to 1,500 feet. A landing was made at Rockaway Beach for the night at about 5:30 p. m. At this time the weather was clear.

During the rest of the trip south to Miami, Fla., few unusual conditions were met except while flying from Hampton Roads to Manteo, N. C., where very heavy fogs were encountered. These fogs were in patches and at times were so dense that it was not possible to see much beyond the ends of the wings. Between the fog patches the visibility was very good. As evening came on the fog disappeared over land and the water for a mile or two to sea, but at that distance it formed almost a solid wall from the water surface to the low-lying clouds.

The weather map of November 1 showed that squally conditions and southwest winds existed over the east gulf and that northwest winds were coming in over north Alabama and Mississippi. As November 2 was the day for the flight from Miami to Pensacola, Commander Read was told that squalls and southwest winds would be encountered along the west coast of the peninsula and that northwest winds, of 15 to 25 knots, would be met during the afternoon and would prevail until Pensacola was reached. The worst squalls of the entire trip were met about noon on the 2d, some appearing so threatening that the course was altered to run around them. All had the characteristic black roll of cloud in front which shows strong vertical currents and each caused a considerable "bump" to be felt as the plane passed under it while at the rear of the roll the down currents caused the usual drop. From encountering these, and a few more, it was found that under squalls of this character the best place to fly is at a low altitude since the up-currents increase in velocity and are more concentrated the nearer the base of the clouds. At low altitudes the air is quite smooth and is the only safe place for dirigibles if they happen to be out at such a time. Following these squalls came the northwest winds and reduced the ground speed to 35 or 40 knots. The flight required 8 hours and 15 minutes, yet the plane landed within 30 minutes of the time it was expected at Pensacola.

One of the most interesting flights was from Pensacola to Memphis, Tenn., via New Orleans, on November 4. The weather map showed thunderstorms to the north and northwest of Pensacola but none west of the Mississippi River. After about two hours flying the radio officer, Lieut. (J. G.) H. C. Rodd, who also acted as radio officer on the trans-Atlantic flight, reported that the static had beome so strong that he could receive no messages and suggested that thunderstorms were in the vicinity. Commander Read inquired if thunderstorms were to be met and was told that they were all to the north and northeast, hence no danger existed. Lieut. Rodd confirmed this with his radio compass by showing the strongest static to exist on a northeast-southwest line. (Lieut. Rodd has explained that the radio compass is so efficient in locating sending stations and storms that often when the static is too strong to receive messages, the radio compass can be set on the sending station and the message received, provided the line of the storm makes more than an angle of 45° with the line to the sending station.) Later a 25 to 30 knot southwest wind was encountered, and Commander Read inquired whether this was to continue or was only local. As the direction was in accordance with the map indications, while the velocity was not, it was reported to be entirely local. This proved to be true a few minutes. These were the only requests made of the Meteorological Officer for information during actual flight.

The next trip from Memphis to Cincinnati furnished another interesting electrical condition which had not been called to my attention before, namely, the static condition which precedes ordinary showers. The antenna of the *NC–4* hung down approximately 250 feet and upon approaching a shower it would become charged so that sparks, from 2 to 4 inches in length, could be drawn by extending a piece of metal or by bringing it close to a metallic part of the plane. This condition is quite different from the ordinary "static" of radio since it produces no sound in the receiver. These sparks were longest about four to five minutes before the rain was reached, at a distance of 4 to 6 miles, since the speed of the *NC–4* was approximately 60 knots. They became smaller, although more frequent, as the distance became less, and died out entirely upon entering the rain. It is said that this condition can usually be noticed even at a land radio station and that the sparks are much larger preceding a snowstorm.

Several instances occurred where the local and map conditions were at considerable variance and made it extremely difficult to determine whether the flight was safe. The best example of this occurred at Vicksburg, Miss. The flight to Natchez was scheduled for December 8, but a trough of low pressure covered the Mississippi Valley and was causing rains and foggy weather throughout that district, hence the flight was postponed. The map on the 9th showed that the depression had made little progress and that the bad weather would continue throughout the day. The sky at Vicksburg was only partly cloudy with low, fast-moving, ragged-edged, cumuli from the south, cirro-stratus from the southwest, and a surface wind from the east. All appearances, as well as the map, indicated a bad day, yet with Natchez only an hour and a half away, it was decided that the flight could be made in good weather and perfect safety. Natchez was reached about 10:30, as was expected, and by 11:30 heavy rain with some thunder and lightning and squally winds occurred.

Probably the biggest surprise of the trip to all hands was the superiority of the air over the Ohio and Mississippi Rivers to that over the Atlantic and Gulf coasts. During clear weather both pilots, at times, released the controls and the *NC–4* flew itself, so smooth was the air. To save distance, bends in the river were jumped so the plane was alternately over water and land, at times over farms, woods, or hills, yet the air was almost invariably smooth. Even when flying not more than 300 feet above the hills between St. Louis and Cairo practically no bumps were felt. Northwest and west winds were always found to be the most bumpy. The worst bump of the trip occurred on the trip from Rockaway Beach to Portland, Me. The plane flew over the Cape Cod Canal at an altitude of 1,800 feet with a strong southwest wind behind her and just as she passed from the land to the water such a severe downward current was met that she almost went into a tail spin. It is said that on the return trip severe bumps or "holes" in the air were found over this peninsula. As would be expected from the fact that hazy or misty air is frequently associated with inversions of temperature, this type of weather along the coasts always furnished the smoothest air for the flights.

In heavy fogs it was found necessary to fly very close to the surface of the water, because it is impossible to fly a large ship like the *NC–4* with safety without a horizon of some kind. Lacking this, as in a fog, the only means of keeping level is to come close to the surface. In the big fog in the Gulf when the *NC–4* was "lost" on December 20 the average height during the afternoon was less than 50 feet, the plane often being so low that the wing pontoons were not more than 10 to 15 feet above the water.

In planning long flights an accurate forecast is needed. On January 2 the plane left Charleston, S. C., for Rockaway Beach, N. Y., a distance of a little over 600 miles. At first it was doubtful if the trip could be made in a single hop, for an active LOW was just passing into the North Atlantic and northwest winds existed from the Great Lakes to the Atlantic coast, with west winds following. After a careful study of the map, Commander Read was told that although northwest winds would exist at Charleston on the morning of the 2d, the *NC–4* would run out of them into fairly strong westerly winds by the time Hatteras was reached and would continue in them the rest of the journey. Under these conditions Rockaway Beach could be reached by evening. The trip was thus planned and the above conditions found. Charleston was left at 7:50 a. m. and Rockaway reached at 5:36 p. m., or 9 hours 46 minutes later. (This was about 25 minutes longer than the time it took the *NC–4* to fly from Ponta Delgada, Azores, to Lisbon, Portugal.) Because of the strength of the wind the average height of the plane during this flight was about 60 feet. From the start to the finish the air was extremely rough, so rough in fact that all members of the crew agreed that it was the worst air they had ever experienced. Following this flight a discussion arose concerning "head winds" and suggested to me the following remarks about the effects of cross winds upon the flight of the plane. A wind 90° to the line of flight, such as a west wind when the plane is flying to a point directly north of it, becomes more and more a head wind as it increases in velocity. It seems as if this should be perfectly evident since the plane must head into the wind, to a certain extent, to overcome the drift, yet it has been noticed that sometimes even those who have had considerable experience in aircraft forget this fact and will maintain that such a wind neither aids nor retards the plane.

NOTES, ABSTRACTS, AND REVIEWS.

NUMBER AND NATIONALITIES OF VESSELS MAKING WEATHER REPORTS TO THE UNITED STATES WEATHER BUREAU.

The following table gives the number of vessels of different nationalities on the Weather Bureau list, October 7, 1920, and the increase or decrease in number and percentage since October 8, 1919.

The decrease noticed in a few cases is due to the fact that the list was gone over thoroughly a short time ago and a number of vessels were taken off that did not appear in Lloyds Register or the Maritime Register, and were evidently out of commission. On the present list there are quite a few vessels that have not been heard from in the last two or three years; they are still in active service, however, and efforts are being made through the different marine centers to persuade their masters to resume the work. These efforts are meeting with considerable success, as shown by the number of old observers who are again sending in reports after a protracted period of inactivity.

Nationality of vessel.	Number on Oct. 7, 1920.	Increase or decrease since Oct. 8, 1919.	Percentage of increase or decrease.
United States Government	109	.....	.....
United States Shipping Board	405	.....	.....
All other American	478	.....	.....
Total American	992	404	68
British	536	10	2
Dutch	152	25	20
Japanese	131	[1] 2	[1] 2
French	73	10	16
Italian	73	18	33
Norwegian	42	2	5
Danish	38	[1] 5	[1] 12
Spanish	36	11	44
Belgian	31	12	63
Swedish	15	4	36
Russian and Finnish	6	[1] 2	[1] 25
Honduran	4	0	0
Chilian	3	2	200
Argentinian	2	1	100
Brazilian	2	0	0
Chinese	2	[1] 2	[1] 50
Interallied	2	1	100
Portuguese	2	0	0
Cuban	1	1	.....
German	1	1	.....
Greek	1	1	.....
Icelandic	[2] 1	1	.....
Mexican	1	1	.....
Peruvian	1	1	.....
Total	2,148	495	30

[1] Decrease. [2] Formerly under Danish flag.

—*F. A. Young.*

DISTRIBUTION OF WEATHER FORECASTS, WARNINGS AND INFORMATION BY RADIO.

In a recent circular (Oct. 26, 1920), the Forecast Division of the Weather Bureau has announced an enlarged plan for the dissemination of weather information, weather forecasts, warnings, and advices to shipping, which has been in actual operation for a number of years, by the office of communications of the Navy Department.

Following is a list of the distributing stations, with their present wave lengths and time of sending:

Station.	Wave length.	Sending time (75th meridian time).
Arlington, Va.	2,500 meters.	Shortly after 10 p. m.
Key West, Fla.	1,500 meters.	Shortly after 10 p. m.
Point Isabel, Tex.	2,350 meters.	Midnight.
Great Lakes, Ill.	1,500 meters.	Shortly after 10 p. m. (Apr. 15–Dec. 20).
San Juan, P. R.	600 meters, damped, followed by 5,250 meters con. wave.	9 p. m. (June to Nov., inclusive).

Each station sends out approximately the same character of bulletins, which are based upon the regular 8 p. m., 75th meridian time, Weather Bureau observation, but vary slightly to conform to the needs of the different sections to be informed. The bulletins are in two parts, the first consisting of the actual weather conditions at certain stations and being in code. The second part is in plain language and is a forecast giving the wind and weather conditions, and whatever information deemed necessary as to storm centers, storm and hurricane warnings.

EXAMPLE OF BULLETIN.

(First part:) USWB J 01662, S 00663, FP 98821, ML 95427, T 95846, NY 93258, DB 92888, LB 95612, CH 94216, AV 98282, C 96682, B 00661, etc.

(Second part:) Winds off Atlantic coast north of Sandy Hook will be shifting gales with rain. Sandy Hook to Hatteras, northwest gales with rains followed by clearing weather. Hatteras to Florida Straits, strong northwest winds; fair weather. Storm of marked intensity central off New Jersey coast moving northeastward. Storm warnings displayed Hatteras to Eastport.

Translation of a small portion of the first part is as follows: United States Weather Bureau, St. Johns, barometer 30.16, wind direction, SW., wind force 2 (Beaufort

scale). Each bulletin is invariably begun with the letters U.S.W.B. Each station has its code letter, as for instance, NY designates New York. The first three figures express the barometric pressure in inches reduced to sea level; the fourth figure is wind direction (1 = N., 2 = NE., 3 = E., etc.); the fifth and last figure is wind force in the Beaufort scale, except when winds of greater force than 9 occur when words instead of figures will be used.

Base charts (size 11½ by 14 inches) of the Atlantic coast extending to the 55th meridian, will be supplied free to vessel masters who regularly take and forward weather observations to the United States Weather Bureau, or to the Hydrographic Office, United States Navy; others may obtain them at a cost of 75 cents a hundred.

A similar service for the Pacific coast is in preparation and will be announced later.

The advantages to be derived from such a service are manifold. While it is primarily intended for coast use, shipping and the like, it would seem that the fruit grower, the cotton grower, and in fact any large business whose following days' work is largely dependent upon the weather would find this service invaluable. Wireless apparatus has been developed to such a state that for less than $10 a simple outfit may be obtained, which is sufficient to receive from the larger stations, if they are not too far away. At the greatest distance from a sending station in this country a $25 outfit would suffice. The writer has an outfit consisting of an aerial, detector, coil, and phones (cost $10) with which he is able to obtain not only Arlington, but many other stations. Arlington sends out comparatively slowly so that it is but a matter of a few weeks practice before one is able to receive well.—*I. F. H.*

LONG INDIVIDUAL METEOROLOGICAL RECORDS.

In a short article on page 413 of the MONTHLY WEATHER REVIEW for July, 1920, reporting the death of a veteran cooperative observer of the Weather Bureau, at the age of 103 years, the author says: "It is believed that this individual record for more than 66 years is unparalleled in this country, if not in the world."

In this connection I beg to call attention to the meteorological record kept by Mr. H. D. Gowey, at North Lewisburg, Ohio, from January, 1832, to June, 1909, a period of 77½ years.

Mr. Gowey began the observations when he was 13 years old, and continued them at practically the same location up to within a few days of his death at over 90 years of age.

The thermometer was read three times a day, and there is scarcely an observation missing during the whole period of time. The temperature observations were begun in 1832, and the rainfall record in 1852. We know of no other individual series of temperature observations of this length in existence.—*J. Warren Smith.*

THE GREAT SUN-SPOT GROUP AND THE MAGNETIC STORM, MARCH 22-23, 1920.

By the Rev. A. L. CORTIE, S. J.

[Abstracted from Monthly Notices Roy. Astr. Soc., 80: 574-578, 1920, April.]

A small spot appearing December 27, 1919, developed into a fine group which had almost died away at the third return February 17–26; revival took place on an immense scale at the next return March 16–29, the group being the greatest since 1917. The months of December, 1919, and January to February, 1920, were magnetically quiet, only a few days being much disturbed. Moderate disturbances accompanied the appearances of the group January 1 and 28, and a more severe storm on February 24; the March revival was accompanied by a magnetic storm of extreme violence March 22–23. All these disturbances appeared at 27-day intervals.

Cortie holds that the greater frequency of magnetic disturbances near the equinoxes is due to the fact that then the heliographic latitude of the earth is in the sun's semiequatorial plane, i. e., in the region of the sun spots; such a position is particularly favorable in the period after the maximum of a sun-spot cycle, when the mean latitude of the sun spots is falling toward the solar equator (*Cf.* M. N., **73:** 58, 1912; **76:** 16, 1915). In the present instance both these conditions were satisfied.

If we suppose that the requisite ionisation of the upper atmosphere is a gradual process as spots begin to grow in number and magnitude, then the advent of a specially active or large spot will suffice to bring about a great storm. In this case there had been a well-marked drop in the values of the monthly ranges of the magnetic elements since October, 1919, indicating that the ionisation of the upper atmosphere due to the successive presentments of the disturbed solar region in December and January was not sufficiently great to cause any but minor disturbances; the conditions were better in February and a moderate storm took place, but the climax was reached in March, when all the conditions—a great disturbed sun-spot region, a favorable heliographic position of the earth, and a highly charged condition of the upper atmosphere—were realized. Anyone of these conditions alone might be sufficient to cause a storm, and hence storms may appear without spots or very small spots; and vice versa, since a large spot need not necessarily be very active. (*Cf.* M. N., **73:** 155, 1913; Astrophys. Jour., **13:** 260, 1901; **49:** 20, 1919). See MONTHLY WEATHER REVIEW, July, 1920, **48**:379.—*E. W. W.*

INTERNAL FRICTION IN THE ATMOSPHERE.

By D. BRUNT.

[Abstracted from *Quar. Jour. Roy. Met'l Soc.*, April, 1920, **46**, 175-185. Shorter abstract in *Nature* (London), Feb. 26, 1920, p. 714.]

The frictional force R acting upon unit volume of the atmosphere may be measured by the amount of horizontal momentum lost per unit of time; this internal friction is chiefly due to eddy viscosity, and according to Taylor the components of R along the axes of x and y are $K\rho d^2u/dz^2$ and $K\rho d^2v/dz^2$, respectively, $R=f(z)$. In the steady state, the forces acting on the air at any level, due to gradient, rotation, and internal friction, must be in equilibrium. Assuming (1), K to be constant throughout the height considered, (2) the gradient wind G to be constant or a linear function of the height z, and (3) the direction of slipping at the boundary to be in the direction of strain, these conditions lead to a vector equation whose solution shows that the wind V at any height is equivalent to G plus an added component $\sqrt{2}G \sin \alpha\ e^{-Bz}$ acting at an angle $\alpha+\frac{3\pi}{4}-Bz$ with the direction of G. This component decreases with height according to the exponential law, rotates its direction uniformly counter-clockwise with increasing height, and sweeps out the equiangular spiral previously treated by Hesselberg and Sverdrup, Ekman,

and Whipple. The equations are equivalent to those of Taylor derived by a different method.

If F denotes the frictional force per unit *surface* acting at any place, then it may be shown that $R=-dF/dz=K\rho\frac{d^2V}{dz^2}$, and $R=\sqrt{2}B.Fe,^{\frac{i\pi}{4}}$ showing that R always acts at an angle $\pi/4$ with the reversed wind direction, which latter itself makes an angle α with the isobar. Now, the angle between R and V, β, can be evaluated and measured independently of any theory whatsoever; this has been done a number of times, the results having been collected and added to by Åkerblom. Taking the mean values of a great number of observations at different localities, it is found that for observations at the top and base of the Eiffel Tower in Paris, particularly in winter, the value of β is in excellent agreement with theory, but for most of the other stations it is poor; this discrepancy can not be explained away by effects of local topography, departure from a steady state, etc. It can be due only to an error in the assumption that K is constant with height. For β to be 45° it is necessary and sufficient that $V=G(\cos\alpha-\sin\alpha)$, independently, again, of any theory; this holds good for Paris, but not for the other places. This relation was derived from *theory* by Taylor on the *assumption* that K did not vary with height.

A discussion of Åkerblom's computations are given; and there is appended a general solution of the problem in the cases where B varies inversely as z or z^2; the solution, however, seems to be open to criticism.—*E. W. W.*

THE GLACIAL CATASTROPHIES IN THE VALLEY OF CHAMONIX IN THE SEVENTEENTH CENTURY AND THE VARIATIONS OF CLIMATE.

By CHARLES RABOT.

[Abstracted from *La Nature*, Aug. 28, 1920, pp. 129-134.]

At the recent *Congres de l'Alpinisme* held at Monaco, an interesting communication relative to the glacial advances and retreats in the valley of Chamonix was presented by Mr. Paul Mougin, the inspector general of waters and forests, and Mr. Letonnelier, registrar of Isère. A record of the movements of the *Mer de Glace* since the year 1600 reveals that that glacier is now at the stage of greatest retreat, and that in 1644 it probably was at a stage of greatest advance. There are records of the destruction of four villages by the glacier in 1644; there are ruins of two remaining to this day, but the location of the remaining two is not known.

There are several evidences of the successive stages of the *Glacier des Bois:* First. The fact the villages mentioned above were located as they were indicates that the mountaineers must have regarded these locations as secure. Such a belief would be founded upon the experience of their forefathers who had probably not been menaced by advancing ice nor by the torrents from the melting ice. This leads to the presumption that perhaps several centuries previous to 1600 there had existed a period of reduced glaciation.

Second. It is known that the Grindelwald glacier in Switzerland experienced a maximum advance about 1601 which was sufficient to destroy villages.

Third. For 250 years after 1600 the fluctuations were such as might accompany a maximum.

Fourth. Since 1850 the retreat has been so marked as to be as conspicuous as was the advance of 1644.

If, therefore, there was a period of maximum glaciation between 1600 and 1850, it is to be supposed that the climatic conditions over Europe were such as to be especially conducive to the formation of ice in the mountains—in other words, there must have been a period of greater cold or increased humidity. Also, the marked decrease in ice in the last 60 or 70 years points to a higher temperature in Europe, or to a decrease in the amount of precipitation, or to an increase in the insolation. Finally, the activity of the glacier in the last 300 years points quite definitely to a climatic variation.

Within these large-amplitude variations are, of course, many short-period variations of small amplitude. For instance, measures made by the observers of the department of waters and forests show since 1914 a maximum annual advance of 117 meters in the case of the Argentière glacier in 1917–18, the total in five years being about 200 meters. The Bois glacier appears to be either stationery or slightly increasing, whereas those of Tour and Bossons show annual movements of the order of 50 meters.[1]—*C. L. M.*

INVERSIONS OF TEMPERATURE IN THE LOWER LAYERS OF THE ATMOSPHERE IN THE ANTARCTIC.

By J. ROUCH.

[Abstracted from *Comptes Rendus*, (Paris Acad.), Sept. 6, 1920, pp. 498-500.]

During the wintering of the Charcot expedition on Petermann Island in the Antarctic at latitude 65° 10′ S. and longitude 66° 34′ W., Paris, temperature observations were made at an altitude of 2 meters and at 35 meters above the ground. The higher station was located upon a hill, and the two stations were about 300 meters apart. The thermometers were exposed in shelters and observations were made at 10 o'clock each day. The results are based upon 202 observations. The differences of temperature by months were as follows:

March.	April.	May.	June.	July.	August.	September.	October.
−0.01	+0.13	+0.45	+0.34	+0.23	−0.17	−0.33	−0.52

The plus sign (+) indicates an inversion.

There were 45 inversions noted in the 202 observations. The greatest inversion amounted to 5.3° C. on July 1.

The effect of wind, temperature, cloudiness, and barometric pressure were studied. It was found that inversions occur most frequently with calms or weak winds. The highest wind with which an inversion occurred was a northeast wind of 20 km. per hour, upon which occasion the inversion amounted to 0.3° C. The lower the temperature the more marked was the inversion. The greatest inversions occurred with clear sky and decreased with increase of cloudiness. The mean barometric pressure was about 740 mm. In no case was an inversion observed with a barometer below 720 mm. The inversions were increasingly frequent with a higher barometer. The registering thermometers indicated that when the diurnal march of the temperature at the upper shelter was plotted against the difference in temperature between the two shelters, the two resulting curves were exactly inverse, a high temperature at the upper station resulting in a minimum of difference.—*C. L. M.*

[1] In this connection, the recent advance of the Grindelwald glacier in Switzerland is of interest. A note in the *Elmira (N. Y.) Herald*, Apr. 13, 1920, says:

"A number of visitors and some scientists are witnessing a strange Alpine phenomenon at Grindelwald, where the famous Grindelwald glacier has been moving into the valley at the rate of 4 to 6 feet daily.

"It has already destroyed a pine forest and crushed a stone bridge across the Black Lutschine into atoms. The ice river continues advancing across the water to the upward bank.

"The rapid movement is due to the enormous amount of ice and snow on the higher portions of the glacier. * * *"—EDITOR.

FACTORS OF CLIMATIC CONTROL.

(A Review.)

Dr. W. J. Humphreys[1] of the United States Weather Bureau has recently prepared a well-balanced and judicious summary of the factors which control climate so far as they are terrestrial in origin. He begins with the statement that small changes of climate occur at the present time, larger ones have apparently occurred in historic times, and still larger ones in the geologic past. These seem to differ in degree rather than nature and are due to a "complex control consisting certainly of all the factors that now are effective, and probably of no others." He then gives a table in which he sums up the known causes of climatic variations. These may be grouped according to the following classifications:

(1) The "*solar variation theory*" is dismissed with a wave of the hand—"seductively attractive—a seemingly complete *reductio ad absurdum.*" Such treatment may seem high-handed, but it is justifiable if, as Humphreys evidently assumes, the term "solar variation theory" means only the old idea that a diminution of the sun's heat would cause glaciation. One of his two brief criticisms is so cogent that it seems effectively to dispose of this old form of the solar hypothesis, although it has no bearing on the other and newer forms. "A change of the solar constant obviously alters all surface temperatures by a roughly constant percentage. Hence, a decrease of the heat from the sun would in general cause a decrease of the interzonal temperature gradients, and this in turn a less vigorous atmospheric circulation and a less copious rain or snowfall—exactly the reverse of the condition, namely, abundant precipitation, most favorable to extensive glaciation."

His other criticism of the solar hypothesis is that geologists agree that times of great climatic changes have usually also been times of great movement of the earth's crust, and hence "great solar changes and extensive mountain building must usually, if not always, have been coepochal—a seemingly complete reductio ad absurdum." In various forms Humphreys has several times repeated this statement in other publications. It is perfectly true that no one has yet published a detailed theory of how mountain building on the earth and climatic variations due to changes in solar activity can be causally connected. This, however, by no means proves that they are not thus connected. The reviewer believes that they are connected, and has nearly completed a manuscript in which this very question is discussed fully. It is not wise to be too positive in such matters, for many things which were deemed impossible a few decades ago are now matters of common knowledge, radioactivity, for example, and the transformation of one metal into another as of the radium products into lead. Moreover, in this whole discussion, it must be noted that Humphreys tacitly assumes that the action of the sun upon the earth is purely thermal, although there is a rapidly growing body of evidence that other agencies, such as electrical energy, or the selection of certain types of solar radiation by the atmospheres of the sun and earth may also play a part.

(2) The next topic in Humphreys' paper is *Croll's eccentricity theory.* As a main cause of glaciation, variations in the eccentricity of the earth's orbit, and hence in the distance of the earth from the sun at different seasons, were discarded three decades ago. They show a rigid periodicity and a frequency wholly out of harmony with the facts of the geological record. Moreover, they do not appear to be quantitatively sufficient. Nevertheless, such variations, together with the cyclical change in the season at which aphelion occurs, must have some slight effect on climate. Hence Croll's theory deserves a permanent though minor place in our discussion.

(3) The *carbon dioxide theory* rightly receives fuller discussion than either of those already mentioned. Abundant evidence is cited which suggests that a layer of carbon dioxide 40 centimeters thick would have practically as much blanketing effect as a layer indefinitely thicker. In other words, that amount of carbon dioxide, while having no effect on sunlight coming toward the earth, would filter out and thus retain in the atmosphere all the outgoing terrestrial heat that carbon dioxide is capable of absorbing. Adding more gas would be like adding another filter when the one in operation has already done all that that particular kind of filter is capable of doing. According to Humphreys' calculations a doubling of the carbon dioxide in the air would raise the average temperature only 1.3° C., and further additions would have practically no effect. Reducing the present supply by half would reduce the temperature by essentially the same amount. Hence this factor alone could scarcely have produced ice ages. Moreover, whatever climatic changes arise from variations in the carbon dioxide of the air must be extremely slow—far too slow to have any relation to short cycles such as those of historic times or even to glacial stages and epochs. Nevertheless they are not too slow to be a contributory factor in producing the longer swings of climate from one geological era to another. Hence we may set down carbon dioxide as a genuine though small factor in causing slow climatic changes, but probably of little importance in the greater and more rapid changes which have chiefly influenced organic evolution.

(4) *The volcanic hypothesis.*—The main body of Humphreys' article consists of a careful and convincing study of the effect of volcanic dust upon terrestrial temperature. He begins with a mathematical investigation of the size of dust particles, and their quantity after certain eruptions. Numerous equations demonstrate that the power of such particles to deflect light of short wave lengths coming from the sun is perhaps 30 times greater than their power to deflect and thereby retain the heat radiated in long waves from the earth. Hence, under circumstances like those which followed the Krakatoa eruption it is estimated that the dust veil might cause a reduction of about 6° C. in the earth's surface temperature, provided the veil continued year after year, as would happen if a Krakatoa were to belch forth dust every year or two. As in every such complicated problem, some of the author's assumptions are open to question, but this touches only their quantitative and not their qualitative value. It seems mathematically certain that if volcanic explosions were frequent enough and violent enough, the temperature of the earth's surface would be lowered.

Actual observation supports this theoretical conclusion. Humphreys gathers together and amplifies all that he and Abbot and Fowle[2] have previously said as to observations of the sun's thermal radiation by means of

[1] W. J. Humphreys: Factors of Climatic Control; Journal of the Franklin Institute, Philadelphia, December, 1919, and January, 1920.

[2] C. G. Abbot and F. E. Fowle: Volcanoes and Climate; Smithsonian Misc. Coll., vol. 60, 1913, 24 pp.
W. J. Humphreys: Volcanic Dust and Other Factors in the Production of Climatic Changes and their Possible Relation to Ice Ages; Bull. Mt. Weather Observatory, vol. 6, pt. 1, 1913, 26 pp.

the pyrheliometer. This summing up of the relation between the heat received from the sun and the occurrence of explosive volcanic eruptions leaves little room for doubt that at frequent intervals during the last century and a half a slight lowering of terrestrial temperature has actually occurred after great eruptions.

(5) *The form of the land.*—The last of the causes of climatic change discussed by Humphreys consists of a group of connected phenomena dependent upon movements of the earth's crust. As to the potency of such movements there is practical agreement among students of climatology and glaciation. That the height and extent of the continents, the location, size and orientation of mountain ranges, and the opening or closing of ocean gateways such as the Isthmus of Panama, and the consequent diversion of oceanic currents, exert a profound effect upon climate can scarcely be questioned. Such changes, however, are slow compared with the rapid pulsations to which climate has been subject during historic times and during the stages of glacial retreat and advance, or even in comparison with the epochs into which the Pleistocene, Permian and perhaps earlier glacial periods have been divided. Hence, while crustal movements are far more important than the eccentricity of the earth's orbit or the amount of carbon dioxide in the air, they do not explain glacial epochs and stages, historic pulsations, and present little cycles of climatic change. All these changes involve a relatively rapid swing from one extreme to another, while an upheaval of a continent, when once accomplished, can not be undone for a long time. Hence, such an upheaval if acting alone, would lead to a relatively permanent climate of a somewhat extreme type. Nevertheless, there is now little question that rapid climatic pulsations are closely associated with great movements of the earth's crust. Hence, some other agency is needed. It must show some logical connection with crustal movements, and yet must be able to vary rapidly and independently. Humphreys believes that volcanic eruptions supply this missing agency—the most important of all the factors involved in our problem. Hence, he comes to this final conclusion: 'Phenomena within the earth itself suffice to modify its own climate, and * * * there is much and accumulating evidence that these and these alone have actually caused great changes time and again in the geologic past."

Few thoughtful students will question that in the 72 pages of his article, which is a section of a book,* Humphreys has made a notable contribution to our knowledge of the climate of the past. He has rounded out the evidence as to the part played by volcanic dust in causing climatic changes, and has put this cause into proper relation with many other known causes. Nevertheless, along two important lines he seems not to have given enough emphasis to factors which are apparently of high importance. In the first place, there is a tacit assumption that, aside from the influence of movements of the earth's crust, the primary cause of all climatic changes must be variations in the amount of heat received, or, at least, retained by the earth. Nevertheless at least a part of the earth's climatic fluctuations apparently occur because alterations in the strength of the atmospheric circulation bring about a redistribution of temperature either directly as a result of stronger winds or indirectly as a result of alterations in cloudiness.[3] In the second place, Humphreys sees so clearly the importance of the purely terrestrial causes of climatic variations that he unconsciously slights the facts as to solar causes which he himself adduces at considerable length. Indeed in this matter he actually contradicts himself. Having said that there is accumulating evidence that "phenomena within the earth itself * * * and these alone have actually caused great changes * * * in the geologic past," he later states that "at least since 1750 * * * and presumably, therefore, since an indefinitely distant time in the past, the two phenomena, atmospheric temperature and sunspot numbers, have in general varied together."

The painstaking work of Köppen,[4] based on 20 million observations in all parts of the world during 100 years, shows the relation of terrestrial temperatures to the sun. Using all available records during the earlier decades and representative records in all parts of the world during later periods, Köppen showed beyond question that during the last century the earth was relatively warm during periods of sunspot minima and cool at times of maxima. The difference was greatest in equatorial latitudes, 0.6° C., and diminished in temperate latitudes, 0.4° C. For the earth as a whole it amounted to approximately one-twelfth of the difference which there appears to have been between the temperature at the height of the glacial period and now. At present either extreme lasts so short a time that it is of slight importance, but if the cooler conditions should persist decade after decade, they would constitute a distinct change of climate.

Köppen's work seems to contradict Humphreys' conclusion as to the paramount importance of terrestrial factors. Humphreys himself points this out without appearing to recognize its significance. On the basis of a much smaller number of stations than Köppen's, he has prepared a curve of terrestrial temperature which goes back to 1750. In its later portions it agrees essentially with Köppen's and shows clearly that the earth's temperature rises when sunspots are few and vice versa. In the earlier parts this is not so evident because the available records are few and imperfect. Nevertheless, even in the 18th century, the curves of sunspots and temperature show so much relationship that there seems good ground for believing that Humphreys is right in his conclusion as to the intimate relation between sunspots and atmospheric temperature "since an indefinitely distant time in the past," and wrong in thinking that phenomena within the earth itself are the only causes of climatic changes. From time to time, however, marked discrepancies appear between the curves of sunspots and of temperature. These in most instances occur immediately after violent volcanic eruptions. Humphreys, following Abbot and Fowle, makes allowance for such eruptions by superposing upon the sunspot curve another curve showing the intensity of the solar heat that reaches the earth's surface. A comparison of this curve with the temperature curve seems to show that at present at least four-fifths of the earth's variations in temperature, aside of course from those due to the seasons, are due to changes in the sun. Nevertheless, the other fifth, or less, seems to be due to volcanic dust or other purely terrestrial causes.

Other studies lead to a similar conclusion. Arctowski[5] in a very careful analysis of monthly temperatures brings

* The physics of the air, Franklin Institute, Philadelphia, 1920. pp. 556-629.

[3] A detailed discussion of this point has been prepared for separate publication.

[4] W. Köppen: Lufttemperaturen, Sonnenflecken und Vulcanausbrüche; Meteorol. Zeitschrift. vol. 31, 1914, pp. 303-328.

[5] H. Arctowski. The solar constant and variations of atmospheric temperature at Arequipa and some other stations. Bull. Amer. Geog. Soc., 1912, **44**: 598-606.

out this point very clearly. By using the departure from the normal seasonal temperature at such stations as Arequipa in Peru, he demonstrates that when the effect of the seasons is eliminated, the earth normally passes through temperature cycles having a length of two or three years. These in turn are superposed upon larger cycles having the eleven-year sunspot period, and these in their turn on still larger cycles. Occasionally these cycles are interrupted by volcanic eruptions. But during the period from 1909 to 1913, which includes the great eruption of Katmai in Alaska, the decrease in temperature due to this cause was less than the difference between the maxima and minima of the cycles in the sunspots. The similarity of Arctowski's curves in different parts of the world seems to demonstrate that the cycles must be due to some outside cause which can scarcely be anything except the sun. Thus both from Köppen's figures and those of Humphreys, Abbot, and Fowle, and from Arctowski's independent and more detailed studies, it appears that at the present time far the greatest control of the earth's temperature is variations in the sun. If a similar relation prevailed in the past, solar variations must have taken their part with terrestrial phenomena among the main causes of geological changes of climate.[6]—*Ellsworth Huntington.*

[6] Geological evidence, however, points to periods of much greater volcanic action than in recent times; while we have no evidence of the occurrence of appreciably greater solar variability. Therefore the terrestrial factors may have been relatively much more important in controlling climatic changes in the geologic past than now.—*Editor.*

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SPECIAL OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1920.

By HERBERT H. KIMBALL, Meteorologist.

[Solar Radiation Investigation Section, Washington, Nov. 1, 1920.]

For a description of instruments and exposures, and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, **48**:225.

The monthly means and departures from normal in Table 1 indicate that solar radiation intensities were close to normal values at Washington, D. C., and Madison, Wis., and above nornal at Lincoln, Nebr., and Santa Fe, N. Mex. At the latter station at noon on September 27, with air mass 1.26, the intensity measured 1.625 calories per minute per square centimeter. This is the highest radiation intensity ever measured at Santa Fe in September. From the intensities measured between this time and 4:40 p. m., when the air mass had increased to 3.80, an atmospheric transmission coefficient of 0.902 is obtained, and extrapolation to zero air mass gives a radiation intensity of 1.84 calories or 1.85 calories if reduced to mean solar distance of the earth.

For the month as a whole there was an excess in the total radiation received on a horizontal surface at all three stations, although for the week beginning with September 3 all stations show a deficiency.

Skylight polarization measurements obtained on 11 different days at Washington give a mean of 58 per cent and a maximum of 67 per cent on the 17th. Measurements obtained at Madison on 11 days give a mean of 69 per cent, and a maximum of 75 per cent on the 16th. These are about average values for September for the respective stations.

TABLE 1.—*Solar radiation intensities during September, 1920.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Suns zenith distance.										
	8 a.m.	78.7	75.7	70.7	60.0	0.0	60.0	70.7	75.7	78.7	Noon.
	75th meridian time.	Air mass.									Local mean solar time.
		A. m.					P. m.				
	e.	5.0	4.0	3.0	2.0	1.0*	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 1	12.24	.....	.....	.....	.....	1.42	1.10	.....	.....	.....	9.47
2	9.14	.....	.....	.....	1.12	1.47	.....	.....	.....	.....	7.29
3	9.47	.....	.....	.....	1.24	1.45	.....	.....	.....	.....	7.57
13	15.11	.....	.....	.....	0.96	1.24	.....	.....	.....	.....	10.21
14	9.83	.....	.....	.....	1.19	1.40	1.16	0.97	.....	.....	9.14
15	10.21	.....	0.79	0.93	1.10	1.27	.....	.....	.....	.....	10.97
16	13.13	.....	.....	.....	0.88	.....	0.92	0.41	.....	.....	14.10
17	7.29	.....	0.98	1.12	1.28	1.46	1.20	1.00	0.84	.....	7.29
18	9.14	.....	0.71	0.83	1.00	1.34	1.04	0.86	0.74	.....	9.83
20	6.76	.....	.....	.....	.....	.....	0.99	0.82	0.63	.....	7.04
21	9.83	.....	.....	.....	.....	1.14	0.84	0.64	0.54	.....	8.18
22	11.38	.....	.....	.....	.....	1.24	1.01	0.78	0.64	.....	12.24
25	17.37	.....	.....	.....	1.02	1.22	0.96	0.78	0.65	.....	18.59
28	16.20	.....	.....	.....	.....	.....	.....	0.96	0.84	0.73	13.61
29	13.13	.....	.....	.....	0.98	.....	.....	.....	.....	.....	10.97
Means	.....	.....	**0.83**	**0.96**	**1.08**	**1.33**	**1.02**	**0.80**	**0.70**	**(0.73)**	.....
Departures	.....	.....	**+0.10**	**+0.07**	**+0.01**	**+0.01**	**−0.03**	**−0.06**	**−0.03**	**+0.06**	.....

* Extrapolated.

TABLE 1.—*Solar radiation intensities during September, 1920*—Contd.

Madison, Wis.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Suns zenith distance.										
	8 a.m.	78.7	75.7	70.7	60.0	0.0	60.0	70.7	75.7	78.7	Noon.
	75th meridian time.	Air mass.									Local mean solar time.
		A. m.					P. m.				
	e.	5.0	4.0	3.0	2.0	1.0*	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Sept. 2	8.81	0.80	0.91	1.03	1.17	1.33	.....	.....	.....	.....	7.29
7	9.83	.....	.....	.....	1.04	1.33	.....	.....	.....	.....	8.48
14	12.68	.....	.....	.....	1.14	1.32	1.02	0.88	.....	.....	13.61
15	19.23	.....	.....	.....	.....	.....	1.24	1.09	0.97	.....	16.20
16	7.29	0.95	1.04	1.15	1.30	1.46	1.26	1.10	0.98	0.89	9.14
17	8.18	.....	.....	.....	.....	1.46	1.16	0.90	.....	.....	8.48
18	9.83	.....	.....	.....	1.08	1.34	.....	0.84	0.68	.....	11.38
21	12.68	.....	.....	.....	.....	1.28	1.00	0.78	0.65	.....	12.68
24	15.65	.....	.....	.....	.....	1.45	1.24	1.01	0.97	.....	11.81
27	12.68	.....	.....	.....	.....	1.42	1.26	1.11	0.98	.....	6.50
28	6.02	.....	1.01	1.13	1.30	.....	.....	1.06	.....	.....	5.36
Means	.....	**(0.88)**	**0.99**	**1.10**	**1.17**	**1.38**	**1.17**	**1.03**	**0.87**	**(0.89)**	.....
Departures	.....	**−0.02**	**+0.08**	**+0.09**	**±0.00**	**+0.02**	**+0.01**	**+0.02**	**+0.02**	.....	.....

Lincoln, Nebr.

Sept. 1	12.68	.....	.....	.....	.....	.....	.....	.....	0.68	0.56	14.60
10	14.10	.....	.....	.....	1.20	.....	.....	.....	.....	.....	15.65
13	12.24	.....	.....	.....	1.19	.....	.....	.....	.....	.....	16.20
15	10.24	.....	.....	.....	1.21	1.42	.....	.....	0.96	0.87	7.04
16	7.29	.....	0.85	1.03	1.24	1.48	1.24	1.05	0.92	0.82	6.76
17	8.18	.....	.....	1.13	1.29	1.48	.....	.....	.....	.....	7.87
18	10.59	0.71	0.82	0.99	1.17	1.39	1.15	0.97	0.82	0.71	12.68
20	13.13	.....	0.66	0.80	.....	.....	.....	.....	.....	.....	16.20
21	10.21	0.83	0.90	1.01	1.17	1.31	.....	.....	.....	.....	11.81
24	16.20	0.94	1.02	1.14	1.29	1.47	.....	.....	.....	.....	10.59
25	9.47	.....	0.83	0.97	.....	.....	.....	.....	.....	.....	11.38
27	7.04	.....	.....	.....	1.33	.....	.....	.....	.....	.....	4.75
29	3.99	.....	1.05	1.18	.....	.....	.....	1.16	1.00	.....	4.37
30	4.17	.....	0.99	1.13	1.30	1.47	1.32	1.15	1.00	0.86	4.37
Means	.....	**0.83**	**0.89**	**1.04**	**1.24**	**1.43**	**1.24**	**1.08**	**0.90**	**0.76**	.....
Departures	.....	**+0.07**	**+0.05**	**+0.05**	**+0.05**	**+0.04**	**+0.09**	**+0.11**	**+0.06**	**+0.02**	.....

Santa Fe, N. Mex.

Sept. 2	8.81	0.88	0.99	.....	.....	.....	.....	.....	.....	.....	7.87
3	7.57	0.93	0.97	1.16	.....	.....	.....	.....	.....	.....	7.87
9	4.75	1.06	1.15	1.25	.....	1.62	1.40	1.24	.....	.....	4.37
10	3.45	1.12	1.21	1.32	1.45	1.59	1.43	1.24	1.15	.....	3.15
11	4.17	.....	.....	.....	.....	1.67	.....	.....	.....	.....	3.00
22	5.79	.....	.....	.....	.....	1.61	1.39	1.21	.....	.....	3.81
23	4.95	.....	.....	.....	.....	1.60	1.39	1.28	1.16	1.05	3.15
27	3.45	.....	.....	.....	.....	1.67	1.50	1.36	1.23	1.11	2.87
30	5.36	.....	.....	.....	1.30	.....	.....	.....	.....	.....	5.56
Means	.....	**1.00**	**1.08**	**1.24**	**(1.38)**	**1.63**	**1.42**	**1.27**	**1.18**	**(1.08)**	.....
Departures	.....	**+0.04**	**+0.02**	**+0.08**	**+0.07**	**+0.10**	**+0.03**	**+0.04**	**+0.05**	**+0.08**	.....

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

[Gram-calories per square centimeter.]

Week beginning—	Average daily radiation.			Average daily departure for the week.			Excess or deficiency since first of year.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Sept. 2	361	320	377	−33	−62	−65	−699	+ 597	.....
10	409	403	451	+27	+51	+34	−509	+ 955	.....
17	429	359	431	+60	+31	+35	− 86	+1,169	.....
24	295	333	450	−55	+29	+72	−474	+1,369	.....

CORRIGENDA.

REVIEW for June, July, and August, 1920, **48:** 358, 420, and 472, respectively, heading of Table 1; sun's zenith distance corresponding to air mass 5.0, *recorded* "77.8" *should be* "78.7."

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By C. G. ABBOT, Assistant Secretary.

(Smithsonian Institution, Washington, Oct. 30, 1920.)

In continuation of preceding publications, I give in the following table the results obtained at Calama, Chile, in August, 1920, for the solar constant of radiation. The reader is referred to this REVIEW for February, August, and September, 1919, for statements of the arrangement and meaning of the table.

The observing station has been moved to a considerably higher altitude and has been provisionally named "Montezuma." The processes used for the values by the "short method" have not yet been perfected for this new station, hence only the values observed by the longer method are at present given.

Date.	Solar constant.	Method.	Grade.	Transmission coefficient at 0.5 micron.	Humidity.		
					ρ/ρSC.	V. P.	Rel. hum.
1920.							
P. M.	*cal.*					*cm.*	*Per cent.*
Aug. 3	1.919	E_o	VG+	.....	0.623	0.09	5
A. M.							
Aug. 4	1.922	E_o	VG−	.....	.744	.11	10
5	1.927	E_o	VG−	.....	.698	.05	4
7	1.932	E_o	E−	.....	.714	.11	9
12	1.932	E_o	E	.....	.616	.18	23
13	1.979	E_o	E	.....	.621	.20	26
17	1.968	E_o	E	.....	.563	.22	23
20	1.924	E_o	VG+	.....	.512	.25	31
21	1.940	E_o	E−	.....	.643	.21	22
23	1.942	E_o	E+	.....	.792	.06	6
27	1.928	E_o	E	.....	.605	.13	10
28	1.951	E_o	E	.....	.669	.13	13
29	1.915	E_o	E−	.....	.536	.24	30
30	1.921	E_o	E−	.....	.564	.24	40
31	1.923	E_o	E−	.....	.599	.18	39

WEATHER OF THE MONTH.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was slightly below the normal at land stations on the American coast north of Florida, and somewhat higher than usual in the British Isles, as well as the Azores and Bermudas, while it was practically normal in the Gulf of Mexico.

The number of days with gales was apparently not far from the normal over the steamer lanes, while they were reported more frequently than usual off the American coast. Most of them occurred in the last decade of the month, including two tropical storms, which will be referred to later.

Fog was unusually prevalent in the vicinity of the British Isles, while the number of days on which it was reported off the American coast and over the Grand Banks was not far from normal, and the middle section of the steamer lanes was comparatively free.

From Greenwich mean noon of the 1st to the 7th light to moderate winds were the rule over the entire ocean, with the Azores HIGH well developed. From the 1st to the 3rd fog was reported over the Grand Banks and off the European coast, while on the 4th and 5th it was confined to the latter region, and on the 6th and 7th the ocean was comparatively free.

Shortly after Greenwich mean noon of the 7th, a disturbance began to develop in the vicinity of Sable Island, Nova Scotia. Extracts from the log book of the American S. S. *Sahale* show that from 9 a. m. until noon (local time) easterly to northeasterly winds of force from 7 to 11 prevailed, the maximum velocity occurring between 11 a. m. and noon, and the minimum barometer reading of 29.34 inches at 11:15 a. m. The noon position on September 7 was given as latitude 42° 40′ N., longitude 62° 42′ W.

The British S. S. *Kaiserin Auguste Victoria* experienced the same storm while not far from the *Sahale*, her noon position, 75th meridian time, being latitude 42° 00′ N., longitude 61° 29′ W. This vessel encountered a southeasterly wind, force 7, at 11 a. m. The wind backed gradually, and at 3:30 p. m. the direction was NW. by N., force 7 to 8. The highest force recorded was 9, and the lowest barometer reading 29.23 inches at 1 p. m.

By Greenwich mean noon on the 9th, as shown on Chart IX, the center of this disturbance was about 250 miles east of St. John's, N. F., and a number of vessels in the southerly quadrants reported westerly and southwesterly gales. The observer on the Dutch S. S. *Rijn* states in the storm log:

Gale began on the 8th. Lowest barometer reading 29.56 inches at 6 a. m. on the 9th; position, latitude 48° 05′ N., longitude 38° 03′ W. End of gale on the 11th. Highest force of wind 10; shifts of wind SSW. to NNW.

This LOW drifted eastward, and on the 11th the center was near latitude 50°, longitude 30°. At the same time Halifax, N. S., was near the center of a second disturbance of limited extent; the observer on the British S. S. *Lancastrian* states in regard to this storm:

September 11, 10 a. m. Latitude 42° 33′ N., longitude 58° 51′ W. Wind SSE. Barometer 29.60 inches. Suddenly hauled SSW., force 8. Barometer falling rapidly. 10:30, hauled SW.-WSW., force 10. Barometer 29.20 inches. 11:30, hauled W. and NW., force 10, squalls of hurricane force, sea increasing rapidly. Barometer 29.18 inches. Noon, hauled N., force 10, high, dangerous sea. Barometer 29.26 inches. 2 p. m., whole gale from NNE. Barometer 29.30 inches, rising slowly. 4 p. m., wind and sea decreasing. Barometer 29.60 inches. 6 p. m., moderate north wind, high NE. swell, barometer 29.75 inches. 10 p. m., light north wind, moderate NE. swell, barometer 29.86 inches. Ends latitude 42° 12′ N., longitude 61° 26′ W. Highest sea in NW. quadrant, short and very precipitous.

The storm log from the British S. S. *Strathfillian* is as follows:

Gale began on the 10th. Lowest barometer reading 29.54 inches at 9:30 p. m. on the 10th; position, latitude 48° 20′ N., longitude 55° 40′ W. End of gale on the 11th. Highest force of wind, 10; shifts of wind, four points.

The observer on the British S. S. *Baltic* states:

Squall began between 8 p. m. and 11 p. m, September 11. Lowest barometer 29.84 inches; position, latitude 51° 10′ N., longitude 14° 40′ W. Highest force of wind 8; shifts of wind SSE. to S.

On the 12th the center of the western LOW was about 250 miles SSE. from St. Johns, N. F., and westerly gales prevailed over the southerly quadrants. On the same day the center of the eastern disturbance was near latitude 51°, longitude 21°; no heavy winds were reported, and the depression was evidently fast filling in. On the 13th and 14th a few reports were received denoting westerly gales over the eastern part of the steamer lanes, and on the latter date heavy weather was also encountered in southern waters, as shown by the storm log of the Belgian S. S. *Olympier:*

Gale began on the 13th. Lowest barometer 29.50 inches, 4 a. m., on the 14th; position, latitude 36° 18′ N., longitude 45° 06′ W. End of gale at noon on the 14th. Highest force of wind 12; shifts of wind, SSE. to NNW.

From the 15th to the 17th, moderate weather prevailed over the entire ocean, with fog over the Grand Banks, and also off the English coast. On the 18th there was a disturbance limited in extent, central in the Irish Channel, accompanied by moderate northwesterly gales off the SW. coast of Ireland, and a southwest wind, force 8, was also reported at the land station at Falmouth, England.

A few vessels that on the 19th were between the 42d parallel and St. Johns, N. F., reported moderate southerly gales, while light to moderate winds prevailed over the rest of the ocean.

Chart X shows the tropical storm that was central in the Gulf of Mexico in Greenwich mean noon of the 21st. A description of this storm at different Weather Bureau stations in Louisana and Texas appears elsewhere,[1] and this article will therefore deal only with reports received from vessels.

According to the daily weather map the center of this disturbance first appeared on the evening of the 19th, near latitude 19°, longitude 86°. It moved in a northwesterly direction, the track of the storm being shown on Chart III.

A letter to the Philadelphia Office, from Captain J. S. Christensen of the American S. S. *Lake Forsby* states:

On September 18, about 10 p. m., while the ship was in the straits of Florida, bound from Philadelphia to Houston, Tex., a radio was received that a tropical disturbance had formed in the Carribean Sea and was moving across the Gulf of Mexico in a NW. direction.

According to extracts from the log, from 8 a. m., September 19, near Sambero Shoal to noon on the 21st,

[1] Cf. this REVIEW, pp. 520-524.

at latitude 26° 40′ N., longitude 87° 38′ W., the vessel experienced light to moderate winds, varying from ENE to SE with falling barometer and partly cloudy to overcast weather during the first part of the period, and heavy rain squalls during the latter. At. 1 p m. the SE. wind had increased to a force of 8, with heavy rain squalls and high sea.

From 2 to 6 p. m. the wind held from the SE., force from 10–11, with the lowest barometer reading of 29.80 inches, occurring near 4:30 p. m., position, latitude 26° 43′ N,. longitude 87° 48′ W., regarding this period the log states:

Two p. m., whole gale, heavy rain squalls. Heavy sea. Slow speed ahead. 4:30 p. m., ship laboring heavily. Using oil to keep sea from breaking on board. Hove ship to on ESE. course. Heavy sea from SE with swell from west. Heavy sea and rain squalls, barometer rising. Six p. m., hove to on ESE. course, heavy sea and rain squalls, barometer rising. 8 p. m., heavy sea and rain squalls, storm subsiding. Hove to on ESE. course. 10 p. m., heavy sea, clear atmosphere, barometer rising. Midnight, 22d, beginning to clear, heavy sea, hove to on ESE. course. 4 a. m. weather clearing, rough sea, full speed ahead, course N. by W. ½ N. Position latitude 26° 40′ N., longitude 87° 16′ W., barometer 29.95 inches.

The observer on the American S. S. *Standard*, states:

At 6 p. m. on the 20th, wind ENE. force 7, barometer 30.01 inches; position, latitude 31.22′ N., longitude 79° 20′ W. 6 p. m. on the 21st, wind NE., force 8; barometer 30 inches; position, latitude 33° 16′ N, longitude 76° 40′ W. Between a. m. and p. m. observations of the 21st, the wind was NE., force 9; between 8 and 12 p. m., NE., force 9–10.

American S. S. *Radiant:*

Gale began on the 20th. Lowest barometer 29.28 inches at 9 a. m. on the 21st, position, latitude 25° 48′ N., longitude 88° 50′ W. End of gale on the 21st. Highest force of wind 12, shifts of wind E. to SSW.

American S. S. *El Rio:*

On the 20th fresh east breeze, sky overcast. 21st a. m. fresh gale. Noon, strong gale, continuous rain, heavy sea. 3 p. m. clearing, and shifting from ESE. to S. 8 p. m. light passing showers, moon showing at intervals, sea decreasing, barometer steady. Midnight, barometer rising, clear sky, fresh southerly wind; 22nd partly overcast, light SW. wind. Position, 8 a. m. 21st, latitude 26° 20′ N., longitude 87° 35′ W. 8 p. m., 21st, latitude 27° 18′ N., longitude 89° 50′ W.

Hondurian S. S. *Yoro:*

Gale began on the 21st. Lowest barometer 29.70 inches at 11 a. m. 21st, position, latitude 26° 02′ N., longitude 86° 06′ W. Highest force of wind, 10; shifts of wind SSE. to S.

On the morning of the 22d as shown on Chart XI, vessels in the vicinity of Hatteras, experienced northeasterly gales, while moderate weather prevailed over the rest of the ocean.

On the 23d there was a disturbance central near latitude 50°, longitude 40°; the observer on the British S. S. *Galtymore*, states in the storm log: "Gale began on the 22d, lowest barometer 29.84 inches at 8 a. m. on the 23d position, latitude 49° 51′ N., longitude 40° 40′ W. End of gale on the 23d. Highest force of wind, 10; shifts of wind SW–W–N." From the 24th to the 27th no heavy weather was reported, and fog prevailed in the vicinity of the British Isles during this period, and off the American coast on the 25th and 26th.

Charts XII, XIII and XIV show the conditions on the 28th, 29th and 30th, respectively, when a disturbance of marked intensity covered an extensive area over the eastern part of the steamer lanes. Storm reports are as follows:

Belgian S. S. *Remier:*

Storm began on the 28th. Lowest barometer 29.12 inches at 7 a. m. on the 28th; position, latitude 39° 40′ N., longitude 23° 39′ W. End of gale October 5. Highest force of wind, 11. Shifts of wind N–S.

British S. S. *Manchester Merchant:*

Gale began on the 27th. Lowest barometer 29.02 inches, at 8 a. m. on the 28th. Position, latitude 51° 50′ N., longitude 24° 56′ W. End of gale on the 30th. Highest force of wind 10; shifts of wind NNW–NW. by N.

Dutch S. S. *Mijdrecht:*

Gale began on the 27th. Lowest barometer 29.69 inches on the 28th; position latitude 38° 14′ N., longitude 35° 00′ W. End of gale on the 28th. Highest force of wind, 10; shifts of wind SW–W–NW–N.

The second Gulf storm of the month was first indicated by a slight depression in the Gulf of Mexico on the evening of the 26th. The track of this storm is shown on Chart III and it did not reach hurricane force until the morning of the 29th. This disturbance was very violent, and among the vessels lost were the American S. S. *Speedwell* and the American schooner *Three Mary's*, while a large number of casualties were also reported.

Mr. Geo. Y. Nicholson, second officer of the British S. S. *Anglo Saxon* reports:

September 29, noon, latitude 25° 23′ N., longitude 83° 14′ W., moderate breeze and sea, partly cloudy, barometer falling steadily. From 4 to 12 p. m. barometer falling and wind holding from SSW., and increasing in force with heavy rain squalls. At midnight barometer 29.61 inches. Wind shifting to SW., latitude 27° 20′ N., longitude 84° 50′ W., September 30, 1 a. m., barometer 29.60 inches, wind veering to NNE. Fresh gale, heavy sea, and continuous rain. Three a. m. barometer 29.55 inches (lowest reading), wind steady NNE., whole gale very heavy; 4 a. m. barometer 29.58 inches. Rain ceased, sky clearing, wind backing to north; 5 a. m. barometer 29.61 inches. Moderate gale, high sea, cloudy and clear; 8 a. m. barometer 29.77 inches, wind increasing slightly; 9 a. m. barometer 29.81 inches. Fresh gale, high sea, fine and clear. Same weather continued until 1 p. m. when barometer read 29.87 inches. Noon position, latitude 28° 03′ N., longitude 85° 35′ W.; 2 p. m. barometer 29.80 inches. Wind lulling at intervals; 4 p. m. barometer 29.89 inches, wind and sea moderate.

At noon on the 29th the position of the American S. S. *West Ashawa* was given as latitude 26° 42′ N., longitude 88° 39′ W., with overcast weather, moderate SE. breeze and barometer reading of 29.57 inches. The barometer continued to fall and the wind to increase steadily. At 4 p. m. the wind shifted to NNE. and reached its maximum force of 12, which held until 5 p. m. when the lowest barometer reading of 29.36 inches occurred. The force of the wind decreased very gradually with the slowly rising barometer, and it was still blowing a moderate gale at midnight on the 30th although it moderated immediately after that hour. The position of the vessel at noon on the 30th was, latitude 25° 55′, N., longitude 89° 58′ W.

The storm logs from a number of different vessels are as follows:

Dutch S. S. *Soesdijk:*

Gale began on the 29th, lowest barometer, 29.41 inches, at 2:30 a. m. on the 30th, position latitude 28° 01′ N., longitude 83° 58′ W. End of gale on the 30th. Highest force of wind, 10; shifts of wind, SSE. to SW.

American S. S. *Westmoreland:*

Gale began on the 29th. Lowest barometer reading 29.40 inches at 8 p. m. on the 29th; position, latitude 32° 01′ N., longitude 80° 50′ W. End of gale on the 30th. Highest force of wind, 9; shifts SE. to NW., through NE.

A late report from the Danish S. S. *Hammershus* shows that on September 10, from 4 a. m. to 2 p. m., while near latitude 20° 07′ N., longitude 50° 36′ W., the ship encountered a severe hurricane, with a maximum force of 12 at 8 a. m. and a minimum barometer reading of

29.08 inches at 8:30 a. m. The direction and force of wind at different hours were as follows:

2 a. m., ENE. 7; 6 a. m., NE. 9; 7 a. m., NE. 11; 8 a. m., NNE. 12; 8:30 a. m., shifting; 9 a. m., NW. 8; 10 a. m., WNW. 10; 11 a. m., W. 11; noon, SW. 10; 2 p. m., SSW. 7.

No other reports were received denoting unusual weather in that vicinity on the 10th, but on the 14th the Belgian S. S. *Olympier* encountered winds of a maximum force of 12 when near latitude 36° N., longitude 46° W., as shown by the storm log of that vessel given above. It is not improbable that this was the same storm in which the *Hammershus* was involved.

This storm must have been of very limited extent, as vessels within a comparatively short distance of the *Hammershus* and the *Olympier* reported only light to moderate winds.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

Atmospheric conditions over the North Pacific Ocean n September presented somewhat different characterstics from those of August. There was about an equal number of storms of tropical origin in each month but those of September maintained their organization into higher latitudes and more gales were reported from the northern part of the ocean. On the other hand the anticyclonic areas of September did not attain either the magnitude or intensity of those of August, although approximating the normal for the month.

As noted in the review of the weather for August a typhoon prevailed in the Philippines at the close of that month. An account of this storm, as well as of subsequent typhoon developments during September, will be found in a note by Rev. José Coronas, S. J., chief of the meteorological division of the Philippine Weather Bureau, on the weather of the Far East, appearing on page — of the REVIEW.

From this report it will be noted that the close of September found another typhoon prevailing in Asiatic waters, as was the case at the end of August. Only a few reports regarding this storm have been received at the present writing and reference to it is therefore reserved for the review of weather for October.

On September 5 there were indications of a depression in the region of latitude 25° N., longitude 170° E. During the 5th and 6th this disturbance moved in a NNW. direction, causing moderate gales in the region traversed. On the 7th it recurved near latitude 40° N., longitude 163° E., and moved rapidly eastward over the Aleutian Islands, at the same time apparently merging with a larger extratropical depression. On the 10th the combined disturbance covered the Gulf of Alaska and was causing moderate to fresh gales over the eastern part of the northern steamer route. This depression reached the British Columbia coast on the 12th.

On the 12th and 13th the American S. S. *Colusa*, Capt. H. L. Jones, Calcutta for San Francisco, was involved in a tropical storm in latitude 24°–24° 30′ N., longitude 149°–152° E. Mr. G. W. Stevens, second officer and observer, in reporting on the weather experienced, states that as early as the 10th there was a small head sea, although the sky was cloudless and there was only a gentle breeze from the ENE. On the 11th rain squalls were experienced and the wind increased somewhat; there was a moderate to rough sea. On the 12th the weather was overcast, with the wind continuing to increase to a whole gale from the SE., accompanied by a large confused sea, generally from the SE., and a large SSE. swell. The ship's course was changed during the height of the storm to bring the wind on the starboard bow. The effect of this was shown, after a time, by a rise in the barometer. The lowest barometer was 29.48 inches, at 10 p. m. of the 12th. Shifts of wind, E. to S. by E.; highest force, 10.

Thus the *Colusa*, which had experienced the typhoon of August 30 when in the harbor of Manila, was within the space of two weeks involved in a second tropical storm, evidently crossing its course just ahead of the center.

The subsequent movement of this storm can not be determined with certainty as yet, but it is probable that it moved on a northwesterly course, recurved near Nippon, and was identical with the storm of marked intensity which appeared to the eastward thereof on the 15th–16th.

This storm, which appears to have been the most important of the month, continued on a course about ENE., toward the Aleutians. Its path can be traced fairly well to the coast of southeastern Alaska, which it reached on the 22d.

The American S. S. *Imlay*, Capt. H. Warrer, Shanghai for San Francisco, was involved in this storm on the 17th and 18th in latitude 43° 46′ N., longitude 159° 165′ E. The lowest barometer was 28.91 inches, which occurred at 11 p. m. of the 17th; highest wind force 11, W.; shifts of wind, SE., S., SW., WNW.

What is considered as an important feature of the weather of September was the gale off the Mexican coast on the 10th. Several ships experienced this disturbance. A typical case is that of the American S. S. *Eastern Glade*, Capt. John N. Ansell, San Pedro for Balboa. Running down the west coast of Mexico, this ship, according to Mr. F. Devine, second officer and observer, had a strong NW. to NNW. wind from the 6th through the 9th. On the 10th, without any great change in the barometer, the wind went to ESE. and increased to a strong gale. During the gale no marked change in the direction of the wind was noted. The lowest barometer was 29.74 inches, at 2 a. m. of the 11th, when in latitude 20° 30′ N., longitude 107° 40′ W.

Mr. A. H. Morris, observer on the American S. S. *West Cayote*, Capt. Chas. Erickson, also from San Pedro toward Panama, reports that the gale was preceded by a moderate SE. swell and very sultry air, but that the barometer gave no indication of a storm. The lowest barometer recorded was 29.78 inches at 12 p. m. of the 9th in latitude 18° N., longitude 104° W. Shifts of wind E. to S., highest force 7.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Canada.—At the end of September there were many prairie fires in Saskatchewan and Manitoba. Sufficient rain fell at the beginning of October to extinguish them, but not before considerable loss had been caused to farmers.[1]

Alaska.—Nome, September 17: Capt. Roald Amundsen's expedition ship, the *Maud*, which left this port nearly two months ago, bound for the North Pole, is caught in the ice about 20 miles off Cape Serge, on the Siberian coast, according to information brought here yesterday by Capt. Heckla, whose fishing boat was also icebound near the *Maud*. * * *.—*New York Times, September 18, 1920.*

British Isles.—In many respects the weather of September was more nearly normal than was the case during the three previous months. * * * The general rainfall expressed as a percentage of the average was: England and Wales, 95; Scotland, 87; Ireland, 87; * * *.

In London (Camden Square) the month was generally cloudy with frequent rain, The mean temperature was 57.9° F., or 0.2° F. above the average.[1]

Continental Europe.—At the beginning of the month anticyclonic areas were situated over Scandinavia and the Azores, and low-pressure areas over Central Europe and Iceland. On the 3d the northern anticyclone moved northward to Spitzbergen, and a depression moving in from Iceland was by the 5th centered over southern Scandinavia, causing very unsettled weather in its passage, with gales over Denmark and the southern Baltic.

Meanwhile the Azores anticyclone began to spread slowly in a northeasterly direction. By the 8th this anticyclone covered southern England, northern France and Germany, and by the 11th it was centered over western Germany, whence it moved slowly southeast.

Pressure still continued high at the Azores and Spitzbergen, and depressions, moving in an easterly direction from Iceland, caused heavy rain in places. At Oxo (southern Norway) 72 millimeters of rain fell on the 15th. On the 16th a depression appeared to the westward of the British Isles, crossed them on the 18th, and reached southern Scandinavia on the 19th, whence it moved northward, and by the 22d was over Spitzbergen. Some heavy rainfalls occurred during this period, especially in France and Switzerland * * *.

By the 22d an anticyclone extended from the Azores to the Baltic, and high pressure was maintained over western and central Europe until the end of the month, although small shallow depressions over France caused local heavy rain. On the last day of the month a deep depression approached the southwest of the British Isles and affected France, causing heavy falls of rain * * *. Temperatures throughout the month were not high except locally in southern Europe * * *.

In Italy and the eastern Mediterranean the weather throughout the month was warm and for the most part fine, except for some local rain in Italy, more especially in the northern districts.[1]

India.—The rainfall in India has been variable, many districts receiving an excess and others a deficiency. The Punjab is badly in need of rain, but the position has improved in the Bombay Presidency, as well as in the Western Deccan, in the United Provinces, in Hyderabad, and in Madras.[1]

China.—The long continued drought in the Honan Province of China has led to severe famine, so that thousands of lives are in danger, and it is estimated that it will take years for the district to recover. A certain amount of rain fell, however, in the Province during September.[1]

Philippine Islands.—Manila, September 13: Heavy loss of life and property damage resulted in the northern Provinces of Luzon Island, of which Manila is the largest city, from the typhoon and floods on August 30, according to advices received to day * * *.

Several towns and villages were practically destroyed, many of the inhabitants being drowned. The damage to rice and tobacco fields was exceedingly heavy.—*New York Times, September 14, 1920.*

Argentina.—A message from Buenos Aires, dated September 22, stated that moderate to heavy rains were falling generally over the Argentine. This rainfall constitutes a definite break in the drought which has been damaging the various crops for a considerable period.[1]

[1] *The Meteorological Magazine*, October, 1920, pp. 207 and 212.

DETAILS OF THE WEATHER OF THE MONTH IN THE UNITED STATES.

CYCLONES AND ANTICYCLONES.

By EDWARD H. BOWIE, Supervising Forecaster.

Five well-defined low pressure and three well-marked high pressure systems crossed the American Continent during the month. The first of the low pressure systems made its appearance over Alaska on August 31, and reached the Atlantic coast on September 7; the second in Alaska on the 6th and 7th, reached the Atlantic States on the 12th; the third in Alaska between the 10th and 14th, reached the Atlantic on the 17th; the fourth, in Alaska on the 20th–22d, reached the Atlantic States on the 26th and the fifth, in Alaska on the 25th and 26th, reached the Atlantic States on the 30th. The first of the high pressure systems was over the Canadian western provinces at the beginning of the month; the second was in the northwest on the 17th to the 19th, and the third in the northwest on the 27th to 29th. In addition to these extra-tropical pressure systems, four disturbances of tropical origin reached the American coasts during the month. The first of these, one of moderate intensity, was off the south Atlantic coast on the 5th and passed thence northeastward along the coast and reached the Canadian Maritime Provinces on the 8th and 9th. The second apparently had its origin on the 17th or 18th, over the southwestern part of the Caribbean Sea and moved thence in a northwesterly direction and its center passed inland over Louisiana during the night of the 21st. Detailed reports of this storm will be found on pages 520–524 of this REVIEW. The second disturbance of a tropical nature passed inland over North Carolina during the night of the 22d; it was of small diameter but of moderate intensity. It is reported to have caused a gale of 72 miles per hour at the mouth of the Cape Fear River during the night of the 22d, carrying the light ship several miles west of its position where anchored. The S. S. *Louisiana* encountered this storm off the Carolina coast on the 22d and estimated the velocity of the wind at 90 miles per hour and from the north. The third disturbance of a tropical character apparently formed over the south central portion of the Gulf of Mexico on the 26th, moved northward and during the evening of the

29th its center was but a short distance south southeast of the mouth of the Mississippi River whence it moved northeastward, crossed the coast line near Cedar Keys, Fla., and then moved northeastward along the coast and reached New England during the night of the 30th. For a detailed report of this disturbance see page 524, above.

Lows.

	Alberta.	Northern Pacific.	Southern Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
September, 1920..	5.0	2.0	2.0	0.0	0.0	0.0	3.0	1.0	1.0	14.0
Average number, 1892-1912.....	4.1	1.0	0.4	0.6	0.7	0.3	0.3	0.2	0.7	8.5

Highs.

	Northern Pacific.	Southern Pacific.	Alberta.	Plateau and Rocky Mountain Region.	Hudson Bay.	Total.
September, 1920.....	2.0	0.0	4.0	2.0	2.0	10.0
Average number, 1892-1912.....	2.0	1.0	3.5	0.7	0.6	7.9

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

[Weather Bureau, Washington, D. C., Nov. 1, 1920.]

PRESSURE AND WINDS.

The variations in atmospheric pressure during September were much better defined than those of the preceding month. In fact, there were several phases of the pressure distribution that attained unusual proportions. A notable high area overspread the northern districts during the first few days of the month, and frequent changes from high to low were observed thereafter. At the end of the month, some of the lowest pressure readings ever observed were recorded at points along the New England Coast.

Two tropical hurricanes entered the Gulf States during the month. The first approached the coast to westward of the mouth of the Mississippi River the night of the 21st–22d and moved during the following day or two as far north as Iowa. The second moved over the Florida Peninsula the night of the 29th–30th and during the following day advanced along the Atlantic coast, causing record-breaking low-pressure readings; and high winds at a few points. More complete details of these storms will appear in another portion of the REVIEW.

For the month as a whole, pressure averages were below normal in all portions of the United States and Canada save along the California coast, where they were slightly above normal. Over the United States the departures were usually small, but in the Canadian Northwest and over the Maritime Provinces they were of considerable extent.

The pressure distribution favored southerly winds over the central valleys, Lake region, and Great Plains, but along the Atlantic coast they were frequently from the northeast, while westerly winds prevailed as usual over the Pacific Coast States.

The general circulation of the atmosphere was not such as to induce high winds, save in connection with the two Gulf storms, and in these cases the wind velocities were mainly high only as they approached the land.

TEMPERATURE

The month as a whole was free from marked temperature changes and only in restricted areas were the extremes of former years equaled. The early part of the month was generally cool over the districts from the Rocky Mountains eastward, and by the end of the first decade cool weather for the season had overspread the far western States. At the same time, however, there was a gradual return to warmer weather over the eastern districts. The middle decade of the month was very generally warmer than normal from the Rocky Mountains eastward, particularly over the Great Plains and central valleys, where warmer weather and sunshine were much needed to bring the late crops, particularly corn, to proper maturity. However, near the end of the decade cooler weather overspread the northern districts from the Great Lakes eastward, and frosts, mostly light, occurred as far south as New Jersey and eastern Pennsylvania.

During the early part of the third decade, warm weather still continued over the principal corn-growing States of the Middle West, but from the Rocky Mountains westward it was mainly cool, particularly about the Middle of the decade, when frosts and freezing weather overspread large areas, and the lowest temperatures ever observed in September were reported from points in Utah and Nevada. Toward the end of the last decade high pressure moved into the northwestern districts from Canada, accompanied by freezing temperatures, and by the morning of the 29th had overspread the Great Plains and central valleys, causing the first severe frost of the season as far south as Kansas. During the closing days of the month the cool area extended into the Gulf States, giving the lowest temperatures for September in a period of 50 years at points in Alabama and other Southern States, and killing frosts extended to Oklahoma, the upper Mississippi Valley, and into the Great Lakes region.

Maximum temperatures above 90° were reported in all the States and they were 100° or above in many of the Southern and Western States. Over the Southeastern States and to westward of the Rocky Mountains the warmest period was near the beginning of the month. Over the remaining districts the warmest days were during the second decade except in the Northeastern States where they occurred near the middle of the last 10-day period.

The lowest temperatures of the month occurred on the last two days, except in the far West where they occurred a few days earlier, and over the Northeastern States where the coldest period was about the 20th.

The average temperature for the month was above normal, though not materially so, over all districts from the Rocky Mountains eastward. In portions of the Ohio Valley and adjacent regions, September was the first month since March with average temperature above the normal. The change to warmer weather during this month was of untold benefit in bringing crops to maturity before the usual period of frost.

West of the Rocky Mountains the monthly averages were mostly below normal, particularly in the Plateau region, where cold weather persisted for long periods.

PRECIPITATION.

Thunderstorm activity was the source of much of the rainfall during the month, and as a result great variations occurred in the amounts received at near-by stations.

The first half of the month was distinctly rainy over the central valleys and southern districts, although periods

with precipitation were not long continued over any extensive areas, nor were the storm movements usually continuous in any particular direction.

Precipitation was fairly general, and in many cases heavy, over most southern States from the 2d to the 4th, extending during the 5th and 6th into the Ohio Valley and adjacent regions and later into New England. Important rains occurred on the 7th and 8th in the Plains States and Rocky Mountain region, and these gradually overspread the central valleys and eastern districts on the 9th and 10th. During this rainy period some unusually heavy falls were reported, notably at Memphis, Tenn., where from the 7th to the 10th the precipitation amounted to nearly 8 inches. Numerous thunderstorms occurred from the 11th to the 13th over an extensive area from the middle Mississippi Valley northeastward to New England, and about the same time rains set in over the far Northwest, some heavy falls occurring near the coast of Oregon and Washington. On the night of the 15th–16th thunderstorms were numerous over considerable areas in the Ohio Valley and to the northward, and locally in Florida and other portions of the South.

In the Rocky Mountain and Great Plains districts rains had very generally ceased by the 12th, and within the following few days clear weather extended into most eastern sections, and but little additional rain occurred in any district until after the end of the second decade. During the night of the 21st–22d a tropical storm approached the Gulf coast somewhat west of the mouth of the Mississippi River, and during the following day or two moved northward, accompanied by rather general rains over a somewhat narrow area. At the same time precipitation set in over the far Northwest and, moving eastward, appears to have united with the southern storm, and rain became general over the greater part of the Missouri and upper Mississippi Valleys on the 23d and 24th. On the latter date some heavy rains were reported rom the Southern States, continuing at intervals and locally for several days, and at the same time rains became general in the far Northwest, extending eastward during the following two or three days along the northern boundary, and developing into an extensive thunderstorm area in the vicinity of the Great Lakes by the morning of the 27th, and extending into the East and South during the following day. Near the end of the month a second tropical storm moved inland from the Gulf, passing over the Florida Peninsula and thence northward along the coast during the 29th and 30th. This storm gave heavy rains over the coast States from Florida to New England, high tides along the Florida coast, and unusually low barometer readings and high winds near the southern New England coast.

Total falls of 10 to nearly 15 inches were reported from many of the southern and eastern States, and in the far Northwest the amounts were in some cases larger, nearly 25 inches being reported from a point in Washington. Over most sections from the Middle Plains eastward the amounts were usually sufficient for present needs. Some heavy rains occurred in Arizona, where but little usually falls during this month, notably in the vicinity of Yuma, where the fall was the heaviest ever recorded in September.

SNOWFALL.

In the mountain sections of the Northwest and at points in the Lake region snow occurred on several dates during the last decade, but the amounts were usually small and soon disappeared.

RELATIVE HUMIDITY.

The average relative humidity was mainly above normal, although there were considerable areas in the vicinity of the Great Lakes and in the Missouri Valley, and local small areas elsewhere that had averages less than normal. The departures either way were usually small except over the northern plateau, where the plus values were locally large.

SEVERE STORMS.

Except in localities affected by the two West Indian hurricanes, high winds were reported usually in connection with local thunderstorms and were confined to small areas.

Near Union, Tenn., a severe storm, probably a tornado, occurred in the afternoon of the 10th. One person was killed and crops and buildings were destroyed or injured to the extent of about $8,000. Near Gouverneur, N. Y., severe thunderstorms on the afternoon of the 12th caused damages to buildings and other property estimated at more than $100,000.

In the vicinity of Providence, R. I., a severe wind and hailstorm occurred on the morning of the 13th. Damage amounting to a million dollars or more was sustained by greenhouse, fruit, truck, and other interests.

At Whitefish Point, Mich., on the southern shore of Lake Superior, a severe storm occurred on the 15th. The wind attained a velocity of about 90 miles per hour, causing much damage to buildings and trees.

At New York City the highest wind ever recorded in September—80 miles per hour—occurred on the 30th in connection with the storm moving up the Atlantic coast at that time.

STORMS AND WARNINGS—WEATHER AND CROPS.

FORECASTS AND WEATHER WARNINGS.

EDWARD H. BOWIE, *Supervising Forecaster.*

Washington Forecast District.—Advices were issued on the 5th in connection with a disturbance that was passing northeastwardly along the Atlantic coast, and on the 6th northeast storm warnings were displayed on the New England coast at and east of New London, Conn. On the morning of the 15th storm warnings were displayed on Lakes Erie, Huron, Michigan, and eastern Superior, when a disturbance of considerable intensity was centered over the upper Lake Region, and following the display strong winds and squalls occurred, but these were not general.

The evening of the 18th the following advisory information was issued and sent to all ports on the southern coasts and to vessels at sea by naval radio:

Conditions are becoming threatening over the western Caribbean Sea and southeast Gulf of Mexico. There are strong indications of a disturbance in an early stage of development east of Yucatan, moving toward the Yucatan Channel. Caution is advised all vessels in east Gulf, northwest Carribbean Sea, Cuban, and south Atlantic waters. Further advices will be issued Sunday morning.

Sunday morning the following bulletin was distributed:

Tropical disturbance central this morning in latitude 18 and longitude 85 and moving slowly north-northwestward toward Yucatan Channel. Apparently of considerable intensity. Vessels in or bound for Yucatan Channel and northwest Carribbean Sea run risk of encountering dangerous conditions.

The subsequent warnings are noted on page 548, below.

Reports of this West Indian hurricane received from vessel masters in the Caribbean Sea and Gulf of Mexico will be found on pages 541–543, below, and a discussion of land observations of it and the damage done as its center passed through Louisiana will be found on pages 520–524, above.

The following excerpts were selected from newspaper editorials in widely separated parts of the United States:

AHEAD OF THE HURRICANE.

The storm now beating against our southern coast did not come as a surprise. Two days ago the Weather Bureau gave public warning of the hurricane's approach and was able, within fairly narrow limits, to tell where and when it would strike and what force would be back of the blow. Probably the shipping saved in this one tornado is greater in value than the cost of the Weather Bureau for years, and one does not like to fix a money value on the great saving of life. * * *—*Chicago Evening Journal, Sept. 22, 1920.*

VALUE OF WEATHER BUREAU ATTESTED.

The importance and value of the United States Weather Bureau service was unmistakably and impressively attested in connection with the terrific storm which on Tuesday night swept up from the Gulf of Mexico and struck the coast of the United States, particularly across Louisiana. Hours before the hurricane had reached the mainland the weather officials knew it was coming. Warnings were hurriedly sent out, not only to the shipping in the Gulf but to the cities, towns, and farms over the section that was threatened. As a result of the warnings, ships and especially the smaller craft out in the open scurried to shelter. Boats that were ready to sail remained in port. On land as well preparations were made to meet the storm. Shelters were constructed, insecure movables were fastened down, exposed goods were covered, contemplated traveling was postponed, trains were given added protection—in short, every possible precaution was taken to withstand the rage of the elements when it should break.

As a result of these preparations it is estimated that many lives were saved and much property loss prevented. The storm came in its fury and much damage was done; for it is not within the ability of man to shield completely the open fields and their crops, his homes, and other possessions from torrential storm and hurricane. But when the violence had abated and a survey of the damage brought realization of what might have been suffered had the storm come unannounced there could not but be universal gratitude and appreciation of the ability of the weather service to forecast the future and send out its beneficial warning.—*Salt Lake Desert News, Sept. 23, 1920.*

A MILD HURRICANE.

* * * * *

The hurricane of this year did not prove as severe as many of its predecessors and the damage was comparatively small. This is partly due to the fact that residents along the coast have been fully educated to the danger of the hurricane and now adopt the sensible plan of getting out of the danger zone as much as possible and protecting their property as well as they can. There is small profit and little sense in the effort by a human being to fight a hurricane. Because of the precautions taken and through the additional fact that the storm was not as severe as has been known in other years, the country escaped with a minimum amount of damage and loss of life.

It must be said for the Weather Bureau in connection with the work of forecasting this storm, that it performed most admirable and valuable service. To predict when and where a West Indian hurricane will arrive at a given point and estimate with any degree of accuracy the condition in which it will arrive is no easy task. Indeed, there are times when the undertaking is simply impossible. There are no observation stations in the middle of the Gulf of Mexico and, lacking these, the Weather Bureau is sorely handicapped by the lack of necessary information.

On this storm, however, the bureau made a most excellent record. It reported its appearance in the western Carribean Sea and estimated the time of its approach as closely as could possibly be done.—*San Antonio Daily Light, Sept. 23, 1920.*

* * * * *

On the 20th advisory information concerning a disturbance east of the Georgia coast was issued. This disturbance, of considerable intensity but apparently of very small diameter, passed inland near and west of the mouth of the Cape Fear River during the night of the 22d. Northeast storm warnings were displayed at 9:30 p. m. of this date at and between Cape Henry, Va., and Wilmington, N. C.

DETECTION OF THE STORM.

That the tropical storm that was detected by the United States Weather Bureau 500 or more miles out at sea spent its fury before coming inland is not the important point. Detection of the storm by the bureau and the ability of the bureau to give the threatened sections of the country information in advance of its coming is the paramount detail. The service rendered shipping at sea and life and property on shore through the timely warnings issued by the bureau may never be estimated. The Weather Bureau has made impossible occurrences of the past when ships went forth to be caught unaware in the teeth of a hurricane and when people ashore slept in fancied security from the coming of blast and flood that wreck property and destroy lives. In this instance, hundreds of ships were held safely in port, while people in seaport towns within the probable sweep of the storm were enabled to make preparations against its coming and summer population at coast resorts that might have been swept away were advantaged by the warning in having been given opportunity to get to places of safety. Cattle on islands that were threatened with submergence were taken to the mainland, and all the section through which the storm was expected to pass was placed in condition of defense against its coming. The Weather Bureau is a great institution and scarcely a week passes that it does not demonstrate its value to the country.—*Charlotte (N. C.) Observer, Sept. 23, 1920.*

On the morning of the 27th advices were issued of the presence of a disturbance of slight intensity over the east-central Gulf of Mexico, and later on that day when the indications of an increase in intensity of this disturbance were apparent additional cautionary advices were broadcast. On the 28th hurricane warnings were

ordered for the Gulf coast at and between Cedar Keys, Fla., and the mouth of the Mississippi River, and southeast storm warnings were displayed on the Florida coast at and between Tampa and Key West. The warnings on the Gulf coast were continued as displayed through the 29th, and all interests were fully warned. The center of this disturbance crossed the Coast Line near Cedar Keys, Fla., during the night of the 29th.

The hurricane warning of September 28 was received at 6.53 p. m., seventy-fifth meridian time; and the order to continue September 29 at 5.22 p. m. These were given the extraordinary dissemination as reported for the warning of September 21.

No damage occurred at Mobile. The value of the warning was in detaining vessels from proceeding to sea.—*Albert Ashenberger*, meteorologist, Mobile, Ala.

A detailed report of this storm and its effects in Florida is published on page 524 above.

The evening of the 29th storm warnings were displayed on the South Atlantic coast at and south of Cape Hatteras, and the morning of the 30th storm warnings were ordered displayed on the middle Atlantic and New England coasts and on Lakes Ontario, Erie, and Huron. This tropical disturbance increased in intensity while moving northeastward along the coast, and gales were general over the regions where warnings were displayed.

Mr. Royal Robbins, Nahant, Mass., made the following report on this storm in New England:

Storm of September 30 on the New England coast.—I have taken some pains to trace the course of the center of the severe tropical storm of September 30 and find it entered New England near New Haven, Conn., thence moving slightly east of north through the valley of the Connecticut River into Vermont, where it lost energy among the mountains. The winds were destructive in Connecticut and western Massachusetts, many thousand trees being blown down, with a number of buildings. In short, between midnight and 4 a. m. October 1 the storm reached nearly hurricane force over the interior of southern New England.

Frost warnings were issued on a number of days during the month.

Chicago Forecast District.—The weather continued mild until the closing days of the month, so that no general warnings were issued until the morning of the 28th.

However, warnings of frost for the cranberry marshes of Wisconsin were issued from time to time during the entire month, and they were for the most part fully verified.

Frost warnings were, moreover, issued on the 28th for the Northern and Central Plains States and Rocky Mountain region, and these were extended eastward to the limits of the forecast district on the 29th and 30th. These predictions were for the most part verified, but there were some failures chiefly in the vicinity of the Lakes because of persistent cloudiness or influence of the water surface.

A critical condition prevailed throughout the Corn Belt from the first of the month because of the lateness of the season, but the ensuing mild temperature proved highly favorable, resulting in maturing most of the corn crop before the close of the month. Special forecasts for continued mild temperature were daily included in the general statements printed on the weather map and on the Corn and Wheat Region Bulletin, as well as telegraphed to the corn and wheat region centers, up to the appearance of the cold high area in the Pacific Northwest on the morning of the 27th.

Special fire-weather forecasts, which had been sent to the District Forester at Missoula for use in connection with the National Forests of Montana, were discontinued for the season on September 13.

Special fire-weather forecasts, beginning September 8, were telegraphed daily to the State forests in Minnesota.

Special long-range weekly forecast was sent to Topeka, Kans., on the 12th for use in connection with the State fair, as follows:

Fair to-night and Monday; rising temperature and conditions favorable for mostly fair weather during the week with rather high temperature.

This forecast proved to be quite satisfactory, as shown by the following extract from the Topeka State Journal:

The biggest free fair in history owes a lot to the Weather Bureau this year for its unqualified success. Of course, the Weather Bureau didn't make the weather to order, but the unprecedented crowds came because they had confidence in the prediction of good weather and good roads.—*H. J. Cox.*

New Orleans Forecast District.—A tropical disturbance moved across the Gulf of Mexico during the 20th and 21st, traveling at the rate of about 22 miles per hour. This disturbance moved inland over Louisiana with its center a little east of and nearly over Morgan City, La. The Central Office issued warnings in connection with this disturbance as follows:

September 20: Northeast storm warnings, 10 p. m., New Orleans, La., to Port Lavacce, Tex., and northwest storm warnings, Corpus Christi to Brownsville, Tex.

September 21: Hurricane warnings were ordered, 10 a. m., for southwest Louisiana and from Port Arthur to Corpus Christi, Tex.

September 21: Change to southeast storm warnings, east Louisiana coast, and continue hurricane warnings southwest Louisiana and Port Arthur to Corpus Christi, Tex., and northwest storm warnings, Brownsville, Tex., 10 p. m. (message received 4:53 p. m.).

September 21: Change to hurricane warnings, New Orleans to Pensacola, Fla., 9 p. m.

The special features connected with the life history of this storm and the damage resulting therefrom will be found in a special paper dealing with this subject (pp. 520–524, above).

Hurricane warnings were ordered for Burrwood, La., 6 p. m., September 28; continued, 6 p. m., September 29, and changed to northwest storm warnings, 11 p. m., September 29. The east Louisiana coast was in the left segment of a disturbance moving northeastward through the Gulf of Mexico, and consequently neither storm winds nor high tides occurred.

Small craft warnings for northerly winds were displayed on the Texas coast 11 a. m. September 29.

Frost warnings were issued September 29 for the Texas Panhandle and Oklahoma, and heavy frosts occurred on the 30th, the first of the season. The high-pressure area did not move eastward as rapidly as expected and light frost occurred October 1 at scattered stations in Arkansas and the interior of Louisiana.—I. M. CLINE.

Denver Forecast District.—Much unsettled weather prevailed in this district during September, but the rainfall was in general light. At Yuma, Ariz., however, 1.48 inches fell in 12 hours on the 15th, which was the heaviest 24-hour reported at regular Weather Bureau stations. Temperatures were somewhat below normal. The first light frost of the month at the moderate elevations occurred at Durango, Colo., on the 7th; this was the first of the season, barring that on the 28th of August, at the same place. Heavy frost occurred at Durango on 10th, 11th, and 22d. Killing frost was reported at Modena, Utah, on the 23d. Frosts, from light to killing, occurred quite generally in Utah, Colorado, and New Mexico on the 24th. Frost warnings were issued for high districts on the 1st, 10th, 11th, 15th, and for all elevations on the 21st, 23d, 25th, 26th, 27th, 28th, 29th, and 30th. These were verified quite generally. A noteworthy fall in temperature occurred at Modena, Utah, on the morning of the 25th when the lowest was 24°, the lowest for September on record.—*A. H. Thiessen.*

San Francisco Forecast District.—The special forecasts made in connection with the saving of the Dutch S. S. *Arakan*, which went ashore near Point Reyes, Calif., on August 29, 1920, are mentioned in a note in the August REVIEW, page 466.

The last fire-weather warning of the season was issued September 1, for the North Pacific States, for warmer weather with drying winds, and it was verified in part only.

Storm warnings were sent to North Pacific seaports on three days and to the north California coast on one day. These were supplemented by small craft warnings on several occasions. In addition to the warnings issued by this office, advices from the Central Office as to conditions being such as to indicate stormy weather in the North Pacific Ocean were received on September 11 and September 20. All warnings were given good distribution and they were for the most part verified.

Light to heavy frost was predicted for Washington, Oregon, and Nevada on the 24th and for Nevada on the 25th.—*E. A. Beals.*

RIVERS AND FLOODS, SEPTEMBER, 1920.

By H. C. FRANKENFIELD, Meteorologist.

The floods that were in progress in the Santee and Trinity Rivers at the end of August were unimportant and had subsided by the middle of September.

The Rio Grande, Sulphur, and Trinity Rivers in Texas and the Canadian River in Oklahoma were in moderate flood during the fore part of the month.

Owing to timely warnings very little preventable loss was suffered. The only losses reported were at Hartingen and Brownsville, Tex., in the Rio Grande Valley, where roads, bridges, etc., were damaged to the extent of about $30,000.

Flood stages during month of September, 1920.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
Santee:	*Feet.*			*Feet.*	
Rimini, S. C.	12	(1)	14	16.4	1
Ferguson, S. C.	12	(1)	18	13.7	1–4
MISSISSIPPI DRAINAGE.					
Canadian:					
Canton, Okla.	3	5	6	4.0	5
Do.	3	8	10	4.6	9
Oklahoma, Okla.	12	15	17	12.4	16
Sulphur:					
Ringo Crossing, Tex.	20	1	3	20.6	2
WEST GULF DRAINAGE.					
Trinity:					
Dallas, Tex.	25	(1)	3	30.9	2
Do.	25	8	15	32.5	12
Trinidad, Tex.	28	8	20	30.4	10
Rio Grande:					
Rio Grande City, Tex.	15	3	14	17.2	12

[1] Continued from August.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, SEPTEMBER, 1920.

By J. WARREN SMITH, Meteorologist.

Frequent rains during the first half of the month delayed farm work in the southern Great Plains area and in many Southern States, and the soil was too dry for fall plowing in the central and western Lake region and parts of the upper Mississippi Valley, although rains the latter part of this period in the western Lake region improved soil conditions in that section, and greatly facilitated the preparation of seed beds for winter grains.

The warm and comparatively dry weather that prevailed the latter half of the month was very favorable for the preparation of the soil, and the seeding of winter grains in the principal grain producing districts, although moisture continued deficient in a few sections, principally in the western Lake region, the southwestern Plains, and in some central Rocky Mountain-Plateau districts. The rainfall in Montana and other areas of the far Northwest was beneficial for fall seeding.

The harvest of a good crop of buckwheat was in progress at the close of the month under favorable weather conditions, while grain sorghums had mostly matured, in excellent condition, in the lower Great Plains. There was considerable delay in late grain thrashing the first part of the month in the central and northern Plains region, and some damage occurred to grain in stack in Kansas. Some interruption to thrashing was caused by frequent showers in the far Northwest also, but thrashing progressed under favorable weather conditions in the northeastern portion of the country.

The uniformly cool weather that persisted during July and August in the principal corn-growing States continued during the first week in September. There was a marked change in temperature conditions thereafter, however, and during the last three weeks in September, temperatures much above normal prevailed throughout the central and northern sections of the country. As the corn crop was late, and there was in many localities apprehension of frost damage before maturity, the change to warmer weather was timely and very beneficial, as the crop matured rapidly and was mostly out of danger of the frost that overspread most of the belt at the close of the month. The crop in general maintained its good to excellent condition throughout the month, and at its close the condition was much above the 10-year average in nearly all sections of the country, particularly in the lower Missouri Valley and Plains States. The Bureau of Crop Estimates reported the condition of corn on October 1, as 124 per cent of the 10-year average in Missouri; 141 per cent in Nebraska; 179 per cent in Kansas, and 186 per cent in Oklahoma.

The temperature averaged near normal in the cotton belt during the first week in September, and there was much cloudy weather, while heavy to excessive rains fell in many eastern and western districts. Thereafter temperatures were uniformly above the average and rainfall was mostly light to moderate. In some sections cotton responded more or less to the better weather conditions, but, as a rule, there was very little general improvement, and at many places a rather marked deterioration was shown. The weather favored rapid opening, however, and picking made good progress in all sections. At the close of the month the condition of the crop was near the average in Texas, Arkansas, Tennessee, and the Carolinas, and considerably above the average in Oklahoma; but at the same time it had fallen to about 80 per cent of the average in the States from Louisiana eastward to Georgia, inclusive, as given by the Bureau of Crop Estimates for September 25.

The weather continued generally favorable for potatoes, truck crops, and tobacco, although it favored late blight in potatoes in northeastern districts; considerable of this disease was reported from New York and Pennsylvania. There was some frost damage in Nevada and Idaho early in the month, while frost occurred in the northeast and in the central Rocky Mountain States during the week ending September 21, but doing no serious damage.

The weather, on the whole, was favorable for pastures, ranges, and stock, and at the close of the month stock were moving rapidly to the lower ranges in the central Rocky Mountain States because of rather heavy snow in the mountains. Stock continued in good condition in nearly all sections of the country.

CLIMATOLOGICAL TABLES.*

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperature and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, September, 1920.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	77.0	+1.7	Thomasville	99	14	Valley Head	34	30	3.31	−0.71	Robertsdale	14.93	Camp Hill	0.02
Arizona	71.5	−1.4	Parker	111	3	Williams	24	26	0.90	−0.19	Snowflake	2.73	5 stations	0.00
Arkansas	74.9	+1.2	Booneville	100	15	Gravette	30	30	3.56	+0.06	Dutton	8.25	Portland	1.10
California	66.4	−2.1	Greenland Ranch	112	3	Portola	20	21	0.30	−0.19	Crescent City	11.59	63 stations	0.00
Colorado	56.4	−0.9	2 stations	98	17†	Crested Butte	−9	27	1.12	−0.27	Holly	3.80	2 stations	0.00
Florida	79.8	+0.6	Switzerland	101	1	De Funiak Springs	39	30	8.09	+1.32	Cedar Keys	14.60	Quincy	2.08
Georgia	76.4	+1.3	Bainbridge	100	2	Tallapoosa	40	30	3.50	+0.05	Brunswick	10.47	West Point	0.76
Hawaii (August)	75.3	+0.6	Mahukona	96	24	2 stations	50	17†	4.31	−1.88	Waiakamoe	18.21	Kaanapali	T.
Idaho	56.8	0.0	Weiser	99	3†	Stanley	18	27	1.59	+0.29	Prichard	5.42	Sugar	0.11
Illinois	69.7	+2.6	8 stations	95	11†	3 stations	34	29†	2.70	−0.87	Griggsville	5.97	Freeport	0.45
Indiana	68.6	+1.6	Wheatfield	96	24	4 stations	36	30	2.85	−0.18	Huntingburg	8.02	Delphi	0.50
Iowa	66.5	+3.1	2 stations	98	20†	2 stations	24	30	3.30	−0.06	Afton	7.21	Cedar Rapids	0.69
Kansas	70.1	+0.6	Colby	103	19	Oberlin	21	30	3.24	+0.22	Quenemo	10.84	Clay Center	0.30
Kentucky	70.8	+0.8	2 stations	96	11	2 stations	38	30	3.30	+0.54	Burnside	6.73	Princeton	1.10
Louisiana	79.9	+2.5	Calhoun	102	11	Ruston	37	30	4.13	−0.02	Audubon Park, New Orleans.	9.95	Shreveport	1.10
Maryland-Delaware	67.7	+0.4	Boyds, Md.	92	25	2 stations	35	3†	3.08	−0.16	State Sanatorium, Md.	5.10	Milford, Del.	1.14
Michigan	62.6	+2.4	2 stations	93	25	Humboldt	25	3†	2.57	−0.57	Charlevoix	5.27	Menominee	0.83
Minnesota	62.3	+4.4	Faribault	95	19	Itasca State Park	22	30	2.76	−0.06	Albert Lea	6.07	2 stations	0.90
Mississippi	78.2	+2.6	3 stations	100	13†	Auguilla	36	30	3.21	−0.19	Bay St. Louis	12.42	Yazoo City	0.43
Missouri	70.0	+1.4	Caruthersville	100	15	2 stations	31	30	4.81	+0.92	Clinton	9.06	Farmington	0.96
Montana	55.6	+0.9	Knowlton	101	17	Bowen	10	14†	1.08	−0.55	Heron	4.28	4 stations	0.00
Nebraska	65.1	+1.4	York	104	19	Gordon	16	29	1.20	−0.93	Fairbury	3.46	Sutherland	T.
Nevada	62.2	−0.1	2 stations	106	1†	Tecoma	20	25	0.32	−0.18	Owyhee	2.00	12 stations	0.00
New England	61.1	+1.7	N. Grosvenor Dale, Conn.	92	26	Garfield, Vt.	25	21†	5.55	+2.00	Torrington, Conn.	9.77	Block Island, R. I.	0.67
New Jersey	66.8	+1.0	4 stations	90	12†	3 stations	30	20	3.87	−0.18	Culvers Lake	8.53	Hammonton	1.67
New Mexico	64.0	−0.4	Pearl	104	18	Red River Canyon	20	13	1.14	−0.42	Des Moines	4.13	2 stations	0.00
New York	62.6	+1.7	Silver Bay	98	27	Gabriels	25	20	4.65	+1.31	Boyds Corners	9.19	Appleton	1.62
North Carolina	71.9	+1.9	3 stations	96	1†	Jefferson	36	30	4.74	+0.95	Southport	13.91	Scotland Neck	1.43
North Dakota	59.0	+2.6	Linton	99	17	Hettinger	19	29	2.22	+0.58	Larimore	7.38	Willow City	0.46
Ohio	66.5	+0.8	Peebles	95	26	2 stations	34	30	2.56	−0.16	Circleville	5.05	Dublin	0.70
Oklahoma	74.3	+0.4	2 stations	103	15†	Oakwood	30	30	3.49	+0.65	Alva	11.20	Bartlesville	1.24
Oregon	58.3	−0.3	Umatilla	99	3	Blitzen	16	24	3.06	+1.83	Government Camp	13.11	Klamath Falls	0.17
Pennsylvania	64.5	+0.9	York	91	26	West Bingham	24	20	3.99	+0.94	Mount Pocono	9.40	Sharon	0.97
Porto Rico	79.3	+0.4	2 stations	98	25	Aibonito	59	6	7.15	−0.90	Cabo Rojo	14.64	Dorado	1.60
South Carolina	75.5	+1.5	Garnett	100	2	Darlington	46	30	5.42	+1.48	Florence, No. 2	10.85	Liberty	1.81
South Dakota	62.7	+2.2	Forestburg	102	13	2 stations	17	29†	1.40	−0.39	Eureka	3.90	Oelrichs	T.
Tennessee	72.4	+1.3	2 stations	96	11†	Sewanee	35	29†	4.02	+0.86	Memphis	10.82	Springville	1.29
Texas	78.9	+1.8	Fairland	107	23	Canadian	34	30	2.17	−0.65	Gatesville	9.90	7 stations	0.00
Utah	59.1	−0.4	St. George	104	2	Blacks Fork	13	26	0.85	−0.26	Highline City Creek	2.62	2 stations	0.00
Virginia	68.9	+0.5	Hopewell	96	25	Burke's Garden	32	18	3.21	−0.16	Hawfield	6.05	Pulaski	1.24
Washington	57.9	0.0	Keystone	98	17	Snyders Ranch	26	26	3.91	+1.69	Paradise Inn	24.10	Wapato	0.20
West Virginia	66.7	+1.0	Glenville	96	28	Terra Alta	34	30	3.14	+0.41	Mannington	5.38	Glenville	1.34
Wisconsin	62.7	+3.1	Wisconsin Rapids	98	14	Tomahawk	18	30	1.88	−1.75	Antigo	4.65	Whitehall	0.31
Wyoming	54.8	−0.1	2 stations	100	18†	Fox Park	13	29	0.87	−0.33	Dutch Joe	2.56	Basin	0.00

* For description of tables and charts, see this REVIEW, January, 1920, p. 54.

† Other dates also.

TABLE I.—*Climatological data for Weather Bureau Stations, September, 1920.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, ice, and sleet on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity.										
																										Miles per hour.	Direction.	Date.							
New England.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*				%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
							62.6	**+ 2.1**													**82**	**4.54**	**+ 1.4**										**5.4**		
Eastport	76	67	85	29.88	29.96	− .07	56.0	+ 0.8	85	24	63	38	19	49	33	53	51		87		3.38	+ 0.4	14	6,425	s.	34	ne.	14	6	8	16	6.8	0.0	0.0
Greenville, Me	1,070	6		28.82	29.98		56.6		84	24	66	30	21	47	41						5.60		15		se.				11	2	17		0.0	0.0
Portland, Me	103	82	117	29.88	30.00	− .05	61.0	+ 1.4	87	26	68	40	20	54	26	56	53		83		8.16	+ 5.0	15	6,092	w.	42	se.	30	11	8	11	5.3	0.0	0.0
Concord	288	70	79	29.69	29.99	− .07	62.2	+ 3.1	88	26	72	38	20	52	36						7.91	+ 4.7	10	3,172	nw.	25	w.	17	15	5	10	5.3	0.0	0.0
Burlington	404	11	48	29.55	29.98	− .08	60.4	+ 1.5	84	26	69	34	21	52	33						5.94	+ 2.6	11	6,331	s.	37	nw.	16	11	5	14	5.8	0.0	0.0
Northfield	876	12	60	29.06	30.01	− .05	57.8	+ 3.2	85	24	69	30	21	47	36	53	51		89		5.56	+ 2.8	13	3,993	s.	29	n.	18	7	9	14	6.4	0.0	0.0
Boston	125	115	188	29.85	29.98	− .09	65.2	+ 2.5	85	25	73	45	20	58	24	59	55		74		1.90	− 1.3	9	6,284	w.	32	s.	30	8	13	9	5.6	0.0	0.0
Nantucket	12	14	90	29.97	29.98	− .10	64.4	+ 1.6	82	26	71	49	22	58	21	60	58		87		1.18	− 1.6	10	9,295	sw.	47	sw.	18	10	9	11	5.4	0.0	0.0
Block Island	26	11	46	29.96	29.99	− .09	65.0	+ 0.9	83	25	70	48	20	60	20	61	59		85		0.67	− 2.3	6	9,970	w.	46	se.	30	13	5	12	5.4	0.0	0.0
Providence	160	215	251	29.82	29.99	− .08	65.2	+ 2.0	89	25	74	42	20	57	26	60	57		81		2.11	− 1.1	9	7,832	nw.	48	s.	30	12	10	8	4.9	0.0	0.0
Hartford	159	122	140	29.82	29.99	− .08	65.6	+ 3.9	88	26	75	41	20	56	29	58	55		75		7.95	+ 4.4	7	4,563	s.	35	s.	30	10	11	9	4.8	0.0	0.0
New Haven	106	74	153	29.89	30.00	− .07	66.0	+ 2.1	85	25	75	42	20	57	27	60	56		74		5.15	+ 1.4	10	6,063	n.	47	s.	30	15	8	7	4.0	0.0	0.0
Middle Atlantic States.							**68.0**	**+ 1.4**													**78**	**3.62**	**+ 0.2**										**4.7**		
Albany	97	102	115	29.89	29.99	− .08	64.4	+ 2.1	89	26	74	41	20	55	28	58	55		78		5.24	+ 2.1	10	4,420	s.	28	ne.	18	14	12	4	4.5	0.0	0.0
Binghamton	871	10	84	29.09	30.01	− .06	63.4	+ 3.4	84	12	74	35	20	53	31						6.04	+ 3.3	12	3,450	nw.	25	ne.	30	7	12	11	5.7	0.0	0.0
New York	314	414	454	29.67	30.00	− .08	67.4	+ 0.9	83	12	74	47	20	60	22	61	57		74		3.24	− 0.4	8	10,774	nw.	80	s.	30	13	10	7	4.7	0.0	0.0
Harrisburg	374	94	104	29.64	30.03	− .05	66.6	+ 1.7	85	26	75	42	20	58	26	60	56		73		5.53	+ 2.7	9	3,707	n.	24	n.	30	14	10	6	4.1	0.0	0.0
Philadelphia	117	123	190	29.90	30.02	− .06	69.6	+ 2.2	84	24	78	48	20	62	24	63	59		75		3.42	0.0	8	5,954	s.	28	n.	13	11	7	12	5.2	0.0	0.0
Reading	325	81	98	29.67	30.02		67.2		85	12	77	41	20	58	29	59	55		72		3.83	+ 0.2	6	3,548	se.	21	n.	1	16	6	8	4.3	0.0	0.0
Scranton	805	111	119	29.17	30.02	− .05	63.9	+ 1.7	84	24	74	37	20	54	31	57	54		76		4.94	+ 2.1	13	4,053	n.	26	sw.	18	7	16	7	5.8	0.0	0.0
Atlantic City	52	37	48	29.95	30.00	− .07	68.6	+ 1.0	87	12	75	48	20	62	23	64	62		82		1.69	− 1.4	6	4,744	s.	37	se.	30	15	11	4	3.7	0.0	0.0
Cape May	18	13	49	30.02	30.04	− .03	69.5	− 0.5	86	12	76	45	20	63	22	64	61		80		2.02	− 1.0	6	5,339	nw.	36	se.	30	17	2	11	4.2	0.0	0.0
Sandy Hook	22	10	57	29.98	30.00		67.6		83	12	73	51	20	62	22	63	61		83		1.73		7	9,658	sw.	63	se.	30	12	13	5	4.7	0.0	0.0
Trenton	190	159	183	29.80	30.00		67.2		85	12	76	44	20	58	27	61	58		77		2.23	− 1.4	9	6,514	s.	36	w.	13	16	11	3	4.2	0.0	0.0
Baltimore	123	100	113	29.89	30.02	− .06	69.8	+ 1.2	87	12	78	49	20	62	25	63	59		72		3.08	− 0.8	7	3,769	nw.	17	n.	19	14	10	6	4.5	0.0	0.0
Washington	112	62	85	29.90	30.02	− .06	68.8	+ 0.7	89	25	78	45	20	59	30	62	59		79		2.87	− 0.7	8	3,522	nw.	24	nw.	30	12	12	6	4.7	0.0	0.0
Lynchburg	681	153	188	29.30	30.04	− .04	69.5	+ 1.1	89	26	79	48	18	60	34	63	60		79		4.51	+ 0.9	9	3,897	e.	24	n.	30	11	12	7	5.0	0.0	0.0
Norfolk	91	170	205	29.92	30.02	− .04	73.9	+ 2.2	89	25	81	56	30	67	21	66	63		76		3.11	− 1.0	9	7,153	ne.	36	nw.	30	14	9	7	4.5	0.0	0.0
Richmond	144	11	52	29.88	30.02	− .05	71.0	+ 0.2	89	25	80	51	18	62	30	65	62		80		2.71	− 0.7	8	4,349	ne.	24	nw.	30	10	13	7	4.9	0.0	0.0
Wytheville	2,304	49	56	27.71	30.04	− .03	65.4	+ 1.8	82	26	74	43	30	56	34	59	58		86		3.39	+ 0.1	13	3,310	e.	20	w.	10	8	17	5	4.6	0.0	0.0
South Atlantic States.							**75.2**	**+ 2.1**													**80**	**6.22**	**+ 1.6**										**5.2**		
Asheville	2,255	70	84	27.75	30.06	− .01	67.2	+ 2.2	82	27	76	41	30	58	26	61	60		88		4.20	+ 1.2	18	4,103	nw.	25	nw.	30	8	10	12	6.1	0.0	0.0
Charlotte	779	55	62	29.19	30.02	− .05	72.7	+ 2.0	89	26	82	48	30	64	28	65	63		79		3.53	+ 0.3	12	2,978	ne.	21	nw.	12	7	13	10	5.4	0.0	0.0
Hatteras	11	12	50	29.98	29.99	− .07	75.4	+ 0.7	88	12	80	63	30	70	18	71	70		85		8.66	+ 3.3	10	8,245	ne.	54	sw.	30	9	12	9	5.5	0.0	0.0
Manteo	12	5	42																																
Raleigh	376	103	110	29.62	30.00	− .07	73.5	+ 2.9	90	25	82	53	30	64	30	65	61		72		2.69	− 0.6	6	5,127	ne.	27	se.	23	8	15	7	5.3	0.0	0.0
Wilmington	78	81	91	29.92	30.00	− .05	75.4	+ 2.3	93	12	83	56	30	68	22						11.09	+ 5.8	12	5,060	ne.	33	e.	22	9	11	10		0.0	0.0
Charleston	48	11	92	29.94	29.99	− .05	77.8	+ 1.6	95	12	85	55	30	71	21	72	70		81		8.30	+ 2.8	12	6,568	ne.	29	ne.	20	10	13	7	5.2	0.0	0.0
Columbia, S. C	351	41	57	29.64	30.02	− .03	76.0	+ 2.3	93	12	85	50	30	67	28	68	65		77		4.17	+ 0.7	8	3,916	ne.	26	w.	9	8	15	7	5.0	0.0	0.0
Greenville, S. C	1,039	113	122	28.93	30.01		72.8		89	12	81	48	30	64	27	65	63		78		2.65		8	5,177	ne.	28	n.	30	11	14	5	4.6	0.0	0.0
Augusta	180	62	77	29.80	30.00	− .05	77.3	+ 2.9	93	12	87	50	30	68	31	70	67		78		6.49	+ 2.8	9	3,207	nw.	29	nw.	9	7	16	7	5.3	0.0	0.0
Savannah	65	150	194	29.92	29.99	− .04	78.2	+ 2.8	96	1	87	52	30	70	25	71	69		81		5.94	+ 0.4	13	6,508	ne.	39	nw.	30	11	13	6	5.3	0.0	0.0
Jacksonville	43	209	245	29.94	29.99	− .01	78.8	+ 1.5	95	12	86	53	30	72	23	73	71		85		7.14	− 0.9	14	7,734	ne.	39	n.	30	10	15	5	4.5	0.0	0.0
Florida Peninsula.							**81.0**	**− 0.3**													**77**	**8.44**	**+ 0.5**										**6.1**		
Key West	22	10	64	29.92	29.94	.00	82.2	− 0.3	91	15	87	71	20	77	16	76	73		75		11.89	+ 5.1	16	5,911	se.	50	sw.	30	7	12	11	6.0	0.0	0.0
Miami	25	71	79	29.95	29.98		80.4	− 1.1	89	14	86	70	30	74	16	75	73		79		6.94	− 2.7	17	5,006	e.	38	s.	30	8	7	15	6.4	0.0	0.0
Sand Key	23	39	72	29.90	29.93	− .01	81.6		89	14	85	69	17	79	16	76	73		74		9.49		13	7,611	e.	58	sw.	30	10	12	8	5.3	0.0	0.0
Tampa	35	79	92	29.93	29.96	− .01	80.3	+ 0.6	92	1	88	62	30	73	19	74	72		81		6.49	− 0.9	12	4,392	ne.	29	n.	30	4	13	13	6.6	0.0	0.0
East Gulf States.							**77.7**	**+ 3.0**													**80**	**5.58**	**+ 1.7**										**5.1**		
Atlanta	1,174	190	216	28.82	30.03	− .02	73.9	+ 1.8	88	2	82	43	30	66	24	67	64		78		3.36	− 0.2	7	6,331	e.	52	nw.	30	14	6	10	4.9	0.0	0.0
Leesburg	279	10	55																																
Macon	370	78	87	29.62	30.01	− .02	76.8	+ 3.9	95	11	87	50	30	67	29	68	66		77		5.77	+ 2.4	11	3,665	ne.	29	nw.	30	8	14	8	5.4	0.0	0.0
Thomasville	273	49	58	29.69	29.98	− .03	78.8	+ 2.0	95	11	88	51	30	70	27	71	68		81		6.07	+ 1.8	11	2,933	ne.	21	e.	26	7	12	11	6.0	0.0	0.0
Pensacola	56	149	185	29.92	29.98	− .01	78.6	+ 0.7	91	15	84	49	30	73	17	73	71		81		12.53	+ 7.3	12	8,776	e.	62	e.	17	2	16	12	6.7	0.0	0.0
Anniston	741	9	57	29.25	30.03	.00	75.1	+ 3.8	91	12	86	41	30	65	31						5.41	+ 1.9	8	3,282	se.	26	nw.	30	14	14	2	3.9	0.0	0.0
Birmingham	700	11	48	29.27	30.03	.00	76.5	+ 2.5	93	1	86	41	30	67	33	68	66		79		4.12	+ 0.6	6	3,813	e.	22	n.	29	9	15	6	4.9	0.0	0.0
Mobile	57	125	161	29.91	29.97	− .03	79.9	+ 3.4	95	16	88	48	30	72	24	73	71		83		7.81	+ 2.8	10	6,649	n.	52	se.	17	6	14	10	5.9	0.0	0.0
Montgomery	223	100	112	29.75	29.99	− .03	78.4	+ 2.6	94	1	87	46	30	70	26	70	67		75		4.20	+ 1.3	6	3,928	e.	29	n.	30	15	7	8	4.3	0.0	0.0
Corinth	469	6					75.8		94	15	87	40	30	65	35						3.71		13		s.				6	20	4		0.0	0.0
Meridian	375	85	93	29.60	29.98	− .04	77.2	+ 4.5	94	16	87	44	30	68	30	70	67		79		2.44	− 1.0	8	3,660	e.	24	nw.	30	18	8	4	3.9	0.0	0.0
Vicksburg	247	65	74	29.72	29.99	− .03	78.1	+ 3.3	92	15	87	45	30	69	26	71	70		83		3.22	− 0.1	6	4,152	n.	34	e.	22	8	19	3	4.8	0.0	0.0
New Orleans	53	76	84	29.91	29.96	− .02	81.5	+ 3.5	96	16	88	54	30	74	25	75	73		84		6.47	+ 1.7	10	4,412	sw.	44	se.	21	5	19	6	5.5	0.0	0.0
West Gulf States.							**78.4**	**+ 2.7**													**76**	**2.03**	**− 1.4**										**3.8**		
Shreveport	249	77	93	29.72	29.98	− .02	78.6	+ 2.9	95	15	88	46	30	69	26	70	67		76		1.10	− 2.1	4	4,491	s.	24	nw.	1	20	7	3	3.1	0.0	0.0
Bentonville	1,303	11	44	28.65	29.99	− .03	70.6	+ 1.7	92	15	81	35	30	60	32						4.50	+ 1.0	7	3,452	s.	20	s.	23	14	6	10	4.1	0.0	0.0
Fort Smith	457	79	94	29.50	29.97	− .04	75.8	+ 3.1	97	24	86	42	30	66	29	67	64		74		2.31	− 0.9	7	4,913	e.	26	w.	8	15	9	6	4.3	0.0	0.0
Little Rock	357	139	147	29.62	29.99	− .04	75.2	+ 2.1	92	15	84	44	30	67	25	68	66		80		2.88	− 0.4	6	5,252	s.	34	n.	1	13	10	7	4.5	0.0	0.0
Brownsville	57	4	26				84.4		100	23	95	58	30	74	29						0.34		4		se.								0.0	0.0
Corpus Christi	20	69	77	29.94	29.96	+ .01	82.0	+ 3.0	93	3	88	60	30	76	20	74	72		80		T.	− 4.0	0	9,195	se.	37	se.	6	19	9	2	3.1	0.0	0.0
Dallas	512	109	117	29.43	29.96		78.1		95	16	87	43	30	69	27						1.72		7	5,562	s.	35	nw.	7	13	12	5	4.1	0.0	0.0
Fort Worth	670	106	114	29.24	29.94	− .05	77.9	+ 1.2	97	23	88	47	30	68	31	69	66		74		2.76	− 0.2	6	6,415	s.	40	se.	6	17	9	4	3.6	0.0	0.0
Galveston	54	106	114	29.92	29.98	.00	81.4	+ 2.0	92	16	86	56	30	76	19	74	71		76		2.86	− 2.6	7	6,939	se.	39	n.	29	20	8	2	3.0	0.0	0.0
Groesbeck	461	11	56	29.47	29.94		78.2		94	16	88	45	30	68	30	70	68		82		3.83		5	6,240	s.	48	ne.	28	13	15	2	4.0	0.0	0.0
Houston	138	111	121	29.82	29.96		80.8	+ 2.3	96	15	90	52	30	72	27						4.30		7	4,921	s.	25	n.	29	18	10	2	3.4	0.0	0.0
Palestine	510	64	72	29.45	29.97	− .02	78.2	+ 3.5	94	16	88	46	30	69	28	70	67		77		3.07	− 0.1	6	4,610	s.	26	s.	6	11	17	2	4.4	0.0	0.0
Port Arthur	34	58	66	29.91	29.95		80.0		94	16	87	51	30	73	24	73	71		79		3.02		6	5,794	s.	35	ne.	29	15	13	2	4.1	0.0	0.0
San Antonio	701	119	132	29.23	29.94	− .02	82.1	+ 5.0	99	23	93	53	30	71	31	70	65		65		0.15	− 2.8	1	5,440	se.	30	n.	29	18	11	1	3.1	0.0	0.0
Taylor	582	55	63	29.39	30.00	+ .03	79.8	+ 2.9	98	23	91	47	30	68	33						0.69	− 2.4	4	5,650	s.	26	n.	29	8	20	2	4.3	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau Stations, September, 1920*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, ice, and sleet on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles.*								*0–10*	*In.*	
							69.7	+ 1.8										77	3.63	+ 0.9										4.8		
Chattanooga	762	189	213	29.25	30.05	− .01	72.9	+ 1.7	88	27	82	43	30	64	30	66	63	80	2.50	− 0.8	12	4,144	ne.	36	nw.	30	5	16	9	5.6	0.0	0.0
Knoxville	996	102	111	28.99	30.03	− .03	71.2	+ 1.8	87	27	80	45	30	63	26	65	63	82	2.51	− 0.3	10	3,249	ne.	23	n.	12	5	10	15	6.5	0.0	0.0
Memphis	399	76	97	29.62	30.04	− .02	74.8	+ 2.0	90	15	83	42	30	67	22	68	65	78	10.82	+ 7.8	9	5,068	n.	32	nw.	1	12	12	6	4.3	0.0	0.0
Nashville	546	168	191	29.47	30.05	− .01	72.2	+ 0.7	90	12	81	40	30	63	29	65	63	79	4.15	+ 0.5	11	5,180	se.	54	nw.	27	10	12	8	5.1	0.0	0.0
Lexington	989	193	230	28.99	30.03	− .04	69.9	+ 2.0	88	21	78	44	30	62	23				4.88	+ 2.5	11	7,454	sw.	40	w.	27	13	7	10	4.6	0.0	0.0
Louisville	525	219	255	29.46	30.04	− .02	71.3	+ 1.4	88	25	80	46	30	62	29	64	61	76	1.79	− 0.8	9	6,651	s.	36	nw.	12	15	7	8	4.0	0.0	0.0
Evansville	431	139	175	29.56	30.03	− .03	72.8	+ 3.1	91	25	82	43	30	64	26	64	61	74	3.36	+ 0.7	11	6,414	sw.	36	w.	27	7	17	6	5.1	0.0	0.0
Indianapolis	822	194	230	29.15	30.03	− .03	69.4	+ 2.7	89	22	79	42	30	60	30	61	56	71	2.37	− 0.7	8	7,047	s.	31	nw.	27	13	8	9	4.5	0.0	0.0
Royal Center	736	11	55	29.23	30.02	.....	66.6	.....	90	25	78	40	30	55	36	58	55	74	1.89	.....	7	5,849	se.	26	w.	28	11	10	9	4.9	0.0	0.0
Terra Haute	575	96	129	29.38	30.00	.....	70.6	.....	90	25	81	43	30	60	30	61	56	69	1.86	.....	5	5,820	s.	37	nw.	11	9	15	6	4.9	0.0	0.0
Cincinnati	628	11	51	29.36	30.03	− .04	67.8	+ 3.1	88	21	77	43	30	58	31				2.98	+ 0.7	9	3,702	sw.	27	w.	11	13	7	10	4.5	0.0	0.0
Columbus	824	179	222	29.18	30.04	− .03	67.2	+ 1.3	87	26	76	41	30	58	29	61	58	79	2.29	− 0.2	9	6,222	se.	30	nw.	30	17	5	8	3.9	0.0	0.0
Dayton	899	181	216	29.06	29.99	.....	67.9	+ 0.5	87	21	78	42	30	58	30	60	56	72	2.62	+ 0.1	8	5,462	sw.	26	sw.	15	16	10	4	3.7	0.0	0.0
Elkins	1,947	59	67	28.03	30.05	− .03	63.4	+ 1.5	83	26	75	40	18	52	35	57	55	87	3.35	+ 0.5	0	2,320	nw.	16	sw.	11	10	10	10	5.7	0.0	0.0
Parkersburg	638	77	84	29.40	30.05	− .03	68.8	+ 2.7	89	27	79	47	30	58	33	61	58	80	3.69	+ 1.0	9	2,904	se.	20	sw.	24	14	8	8	4.6	0.0	0.0
Pittsburgh	842	353	410	29.14	30.03	− .03	66.8	+ 0.7	85	27	75	46	30	58	26	59	55	73	3.48	+ 1.0	10	6,380	nw.	36	w	9	9	11	10	5.2	0.0	0.0
Lower Lake Region.							64.8	+ 1.7										73	3.14	+ 0.3										4.2		
Buffalo	767	247	280	29.19	30.01	− .05	64.3	+ 1.4	84	26	72	42	20	57	26	58	54	73	2.03	− 1.2	10	9,630	s.	50	sw.	18	9	12	9	5.2	0.0	0.0
Canton	448	10	61	29.50	29.97	.....	61.4	+ 2.1	88	25	72	32	20	51	34				5.11	+ 2.3	11	5,342	w.	48	sw.	27	14	9	7	4.0	0.0	0.0
Oswego	335	76	91	29.63	29.99	− .07	63.1	+ 0.4	84	27	70	42	20	56	24	57	54	78	4.31	+ 1.5	13	6,853	s.	46	ne.	30	15	8	7	4.1	0.0	0.0
Rochester	523	86	102	29.45	30.02	− .04	64.5	+ 2.6	88	27	74	38	20	55	29	57	53	72	3.30	+ 1.0	11	5,183	sw.	36	sw.	27	15	10	5	4.1	0.0	0.0
Syracuse	597	97	113	29.38	30.02	− .05	63.2	+ 1.6	84	26	72	40	20	55	25				6.62	+ 3.8	12	6,690	s.	35	nw	12	10	13	7	5.2	0.0	0.0
Erie	714	130	166	29.25	30.01	− .05	65.4	+ 1.5	84	22	73	43	20	58	25	59	55	72	1.75	− 1.7	8	8,821	se.	37	w.	18	15	7	8	4.3	0.0	0.0
Cleveland	762	190	201	29.21	30.03	− .03	65.8	+ 1.5	86	22	73	47	30	59	25	59	55	70	1.85	− 1.4	5	8,341	s.	46	ne.	30	18	5	7	4.0	0.0	0.0
Sandusky	629	62	103	29.35	30.02	− .04	66.8	+ 1.5	85	23	75	48	20	59	25				2.82	+ 0.1	7	7,578	s.	46	n.	30	14	11	5	4.1	0.0	0.0
Toledo	628	208	243	29.35	30.03	− .03	66.6	+ 2.5	89	25	76	43	30	58	27	59	55	73	2.23	− 0.1	6	8,533	sw.	41	se.	9	19	5	6	3.3	0.0	0.0
Fort Wayne	856	113	124	29.11	30.03	.....	66.4	+ 0.9	89	25	77	40	30	56	34	58	54	72	1.69	.....	6	5,042	s.	29	sw.	26	13	10	7	4.4	0.0	0.0
Detroit	730	218	245	29.24	30.03	− .03	65.7	+ 2.6	88	25	74	44	30	58	27	58	54	74	1.37	− 1.1	7	7,636	w.	36	n.	30	16	8	6	3.9	0.0	0.0
Upper Lake Region.							62.7	+ 3.6										76	2.26	− 1.0										4.5		
Alpena	609	13	92	29.35	30.02	− .01	59.4	+ 2.1	80	22	68	37	19	51	31	56	53	84	4.20	− 0.8	10	7,249	se.	40	se.	11	13	9	8	4.9	0.0	0.0
Escanaba	612	54	60	29.34	30.00	− .01	59.4	+ 2.5	76	15	67	34	30	52	26	55	52	79	2.95	− 0.6	7	6,314	s.	34	ne.	18	19	9	2	2.6	0.0	0.0
Grand Haven	632	54	89	29.32	29.99	− .05	63.6	+ 2.5	86	23	72	40	30	55	29	58	55	77	1.56	− 1.6	7	7,005	s.	34	nw.	28	14	13	3	3.8	0.0	0.0
Grand Rapids	707	70	87	29.25	30.01	− .04	65.9	+ 4.1	90	25	76	40	30	55	37	58	54	72	3.68	+ 0.6	8	3,598	se.	26	w.	12	10	11	9	5.1	0.0	0.0
Houghton	684	62	96	29.25	29.97	− .03	59.8	+ 3.7	90	14	70	34	30	50	38				1.00	− 2.5	10	6,485	e.	44	w.	15	10	16	4	4.5	0.0	0.0
Lansing	878	11	62	29.08	30.02	.....	64.2	+ 2.9	91	25	77	37	30	52	36	56	53	79	1.26	− 1.4	7	3,288	s.	22	sw.	28	13	8	9	5.2	0.0	0.0
Ludington	637	60	66	29.30	30.00	.....	62.0	.....	85	23	70	40	30	54	29	57	54	77	1.99	.....	6	6,600	s.	37	w.	28	14	10	6	3.8	0.0	0.0
Marquette	734	77	111	29.21	30.01	+ .01	60.8	+ 4.0	86	14	70	39	30	52	30	54	51	76	1.94	− 1.6	9	6,501	w.	31	w.	28	6	12	12	6.1	0.0	0.0
Port Huron	638	70	120	29.32	30.01	− .05	63.6	+ 2.7	88	25	73	42	30	54	30	57	53	75	1.82	− 0.9	6	7,051	nw.	36	ne.	30	13	12	5	4.1	0.0	0.0
Saginaw	641	69	77	29.32	30.02	.....	63.6	.....	89	25	74	39	30	53	35	57	54	76	1.09	− 2.0	5	5,373	se.	29	sw.	28	15	8	7	4.4	0.0	0.0
Sault Sainte Marie	614	11	52	29.32	30.01	− .01	59.2	+ 4.9	85	22	69	32	19	49	30	53	50	79	3.72	+ 0.3	9	4,611	se.	40	nw.	16	9	9	12	5.7	0.0	0.0
Chicago	823	140	310	29.13	30.00	− .04	69.3	+ 4.7	90	21	76	43	29	63	25	61	56	68	3.35	+ 0.3	7	8,351	nw.	35	s.	15	14	12	4	3.8	0.0	0.0
Green Bay	617	109	144	29.33	29.99	− .02	63.0	+ 3.9	87	25	72	36	30	54	31	55	51	74	0.91	− 2.2	7	7,531	s.	39	w.	28	11	13	6	5.3	0.0	0.0
Milwaukee	681	125	139	29.26	29.99	− .04	66.7	+ 5.2	90	21	74	39	29	59	27	59	55	72	2.78	− 0.1	7	7,360	se.	29	sw.	15	13	14	3	3.9	0.0	0.0
Duluth	1,133	11	47	28.75	29.96	− .02	60.3	+ 3.6	88	25	69	30	30	52	31	54	51	79	1.31	− 2.2	7	8,368	ne.	39	w.	15	15	6	9	4.3	T.	0.0
North Dakota.							60.0	+ 2.8										71	2.65	+ 1.2										4.8		
Moorhead	940	8	57	28.92	29.93	− .03	61.5	+ 4.9	91	13	73	26	30	50	39	54	51	80	3.46	+ 1.2	15	5,134	se.	29	s.	25	16	2	12	4.9	0.0	0.0
Bismarck	1,674	8	57	28.16	29.93	− .01	60.3	+ 3.2	94	17	73	25	30	47	48	51	45	66	1.20	0.0	7	6,386	nw.	35	nw.	28	12	9	9	4.7	T.	0.0
Devils Lake	1,482	11	44	28.32	29.88	− .06	59.4	+ 3.8	90	17	71	33	30	48	41	51	46	73	5.34	+ 4.0	10	6,590	se.	34	e.	18	15	6	9	4.6	T.	0.0
Ellendale	1,457	10	56	28.36	29.91	.....	60.2	.....	91	17	72	26	29	48	44	54	50	78	3.19	.....	12	8,329	nw.	54	nw.	14	6	11	13	6.0	T.	0.0
Grand Forks	835	12	89	.....	.....	.....	59.8	.....	88	17	72	25	30	47	44	53	.....	.....	3.10	.....	14	.....	se.	31	nw.	15	14	6	10	.....	0.0	0.0
Williston	1,878	41	48	27.91	29.87	− .06	58.8	− 0.7	96	17	72	25	29	46	52	49	41	59	0.60	− 0.3	6	5,372	se.	36	nw.	28	15	12	3	3.8	0.0	0.0
Upper Mississippi Valley.							68.1	+ 3.2										74	2.73	− 0.6										4.5		
Minneapolis	918	102	208	28.96	29.93	.....	65.5	.....	91	25	75	40	29	56	31	.....	.....	.....	1.95	− 1.7	9	8,332	se.	46	se.	25	14	7	9	4.9	0.0	0.0
St. Paul	837	236	261	29.06	29.96	− .03	65.0	+ 4.7	90	25	74	39	29	56	31	.....	.....	.....	1.36	− 2.1	10	8,560	se.	57	s.	25	13	12	5	4.3	0.0	0.0
La Crosse	714	11	48	29.21	29.97	− .04	64.5	+ 2.8	89	25	76	33	30	54	34	.....	.....	.....	0.81	− 3.3	7	3,019	s.	20	w.	28	13	8	9	4.7	0.0	0.0
Madison	974	70	78	28.97	30.00	− .03	65.5	+ 4.4	89	25	75	37	29	56	31	57	53	72	1.12	− 2.1	6	5,986	s.	26	w.	28	11	9	10	5.4	0.0	0.0
Wausau	1,247	4	.....	28.66	29.98	.....	60.3	.....	87	25	72	33	30	49	39	.....	.....	.....	1.44	.....	7	.....	nw.	.....	.....	.....	14	6	10	5.1	0.0	0.0
Charles City	1,015	10	49	28.91	29.98	− .02	64.4	+ 2.7	88	25	74	34	30	54	31	58	55	80	5.76	+ 3.0	11	3,973	s.	22	se.	19	11	11	8	4.9	0.0	0.0
Davenport	606	71	79	29.34	29.99	− .04	68.8	+ 4.1	91	25	79	37	29	58	29	60	55	71	1.85	− 1.3	7	4,743	sw.	30	sw.	15	15	8	7	4.3	0.0	0.0
Des Moines	861	84	97	29.06	29.96	− .06	68.0	+ 3.0	89	25	78	36	30	58	30	59	55	72	4.44	+ 1.4	9	4,692	s.	36	sw.	23	14	9	7	4.3	0.0	0.0
Dubuque	698	81	96	29.26	30.00	− .03	66.4	+ 2.8	90	25	76	34	30	56	31	59	55	75	1.46	− 2.1	6	4,046	s.	24	nw.	28	15	8	7	4.4	0.0	0.0
Keokuk	614	64	78	29.33	30.00	− .03	69.5	+ 3.1	91	25	79	38	30	60	29	61	56	70	2.65	− 1.3	8	4,733	s.	34	nw.	11	12	11	7	4.6	0.0	0.0
Cairo	356	87	93	29.63	30.00	− .05	73.0	+ 2.8	91	15	82	41	30	64	26	65	62	77	2.19	− 0.3	8	5,172	s.	29	n.	29	7	15	8	5.1	0.0	0.0
Peoria	609	11	45	29.35	30.02	− .02	68.5	+ 4.2	91	25	80	38	29	57	33	60	57	76	1.84	− 1.3	7	3,689	s.	17	sw.	11	14	11	5	4.0	0.0	0.0
Springfield, Ill.	644	10	91	29.32	29.99	− .06	69.5	+ 3.1	88	14	79	40	30	60	27	62	58	77	3.08	− 0.3	8	5,162	s.	33	nw.	11	12	13	5	4.1	0.0	0.0
Hannibal	534	74	109	29.42	29.99	− .04	69.6	+ 1.7	91	14	80	40	30	60	31	.....	.....	.....	4.92	+ 1.4	8	5,377	sw.	32	nw.	11	14	11	5	4.2	0.0	0.0
St. Louis	567	265	303	29.40	30.00	− .04	72.5	+ 2.5	91	14	80	45	30	65	22	63	58	67	4.79	+ 1.9	8	8,269	s.	44	s.	10	15	12	3	3.7	0.0	0.0
Missouri Valley.							67.7	+ 2.4										71	2.69	0.0										3.7		
Columbia, Mo.	781	11	84	29.17	29.99	− .04	69.6	+ 1.8	89	14	79	38	30	60	30	.....	.....	.....	4.47	+ 1.6	8	4,728	se.	28	w.	13	16	7	7	3.7	0.0	0.0
Kansas City	963	161	181	28.96	29.97	− .05	70.6	+ 3.1	90	20	79	38	30	62	24	62	58	72	4.30	+ 0.5	10	7,191	s.	36	n.	10	16	8	6	4.0	0.0	0.0
St. Joseph	967	11	49	28.94	29.96	.....	69.4	.....	92	20	80	36	30	59	31	61	58	74	5.04	.....	10	4,803	s.	33	s.	23	18	6	6	3.4	0.0	0.0
Springfield, Mo.	1,324	98	104	28.62	30.01	− .02	70.0	+ 2.1	87	15	78	36	30	62	24	63	60	78	4.42	+ 0.7	8	6,726	se.	37	se.	13	21	6	3	2.7	0.0	0.0
Iola	984	11	50	28.95	29.97	− .04	71.0	+ 2.4	91	15	82	37	30	60	32	.....	.....	.....	4.18	+ 0.8	10	3,971	s.	22	n.	3	11	11	8	4.8	0.0	0.0
Topeka	987	92	107	.....	.....	.....	69.8	+ 1.5	92	20	80	34	30	59	32	.....	.....	.....	4.02	+ 0.5	11	6,058	s.	36	n.	2	17	8	5	3.8	0.0	0.0
Drexel	1,299	10	53	28.57	29.95	.....	66.3	.....	94	19	79	29	30	54	37	58	55	70	0.99	.....	6	6,327	s.	45	sw.	25	16	13	1	3.5	0.0	0.0
Lincoln	1,189	11	84	28.69	29.94	− .05	68.8	+ 3.6	96	19	81	32	30	57	38	59	54	68	1.44	− 1.2	8	5,477	s.	38	s.	12	11	14	5	4.1	0.0	0.0
Omaha	1,105	115	122	28.80	29.96	− .04	68.8	+ 3.0	94	19	80	34	30	58	36	60	56	70	1.03	− 2.0	8	4,780	nw.	33	n.	28	15	11	4	3.7	0.0	0.0
Valentine	2,598	47	54	27.25	29.94	− .02	63.6	+ 1.3	97	18	78	28	30	50	45	53	46	64	2.33	+ 0.5	9	6,213	sw.	39	s.	20	19	10	1	2.8	0.0	0.0
Sioux City	1,135	94	164	28.75	29.95	− .03	66.6	+ 2.7	91	25	78	30	30	55	37	57	53	69	1.94	− 0.5	7	7,656	s.	53	s.	25	19	7	4	3.2	0.0	0.0
Huron	1,306	59	74	28.55	29.93	− .03	63.5	+ 3.9	91	18	75	27	30	52	38	56	51	72	1.93	+ 0.2	4	6,302	s.	44	nw.	14	16	8	6	3.8	0.0	0.0
Pierre	1,572	70	75	28.26	29.90	− .05	64.5	+ 1.7	97	18	77	31	30	52	52	56	52	73	0.98	− 0.1	7	5,313	nw.	36	nw.	14	16	7	7	3.8	0.0	0.0
Yankton	1,233	49	57	28.63	29.93	− .05	65.6	+ 2.3	93	18	78	30	30	53	40	.....	.....	.....	1.25	− 1.2	5	5,053	s.	38	sw.	23	15	11	4	4.0	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau Stations, September, 1920*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, ice, and sleet on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity.								
																									Miles per hour.	Direction.	Date.						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.		°F.	°F.			%	In.	In.		Miles.						0–10	In.	In.
Northern Slope.							58.0	+ 0.6													58	1.07	− 0.1								4.4		
Billings	3,140	5					58.2		98	18	76	27	29	41	54							0.16		4					9	17	4		0.0	0.0
Havre	2,505	11	44	27.25	29.86	− .08	58.7	+ 1.1	91	16	73	28	29	44	51	49	42	63				0.34	− 0.7	9	4,951	sw.	35	sw.	14	15	11	4	3.9	0.0	0.0
Helena	4,110	87	112	25.75	29.89	− .08	56.9	+ 0.7	87	16	69	36	15	45	41	46	37	54				1.39	+ 0.3	8	4,934	sw.	28	sw.	25	10	8	12	5.3	T.	0.0
Kalispell	2,973	48	56	26.85	29.88	− .08	54.2	+ 0.3	82	17	62	34	23	42	38							0.70	− 0.6	8	3,779	nw.	24	w.	14	14	7	9	6.6	0.0	0.0
Miles City	2,371	26	48	27.40	29.93	− .02	64.2	+ 3.0	96	17	77	27	29	51	44	53	47	64				0.36	− 0.6	5	3,885	se.	36	nw.	14	14	14	2	3.6	0.0	0.0
Rapid City	3,259	50	58	26.58	29.95	− .01	60.4	+ 1.3	92	16	73	28	29	47	45	49	40	53				0.99	− 0.3	9	5,102	w.	33	nw.	28	13	9	8	4.5	0.0	0.0
Cheyenne	6,088	84	101	24.05	29.94	− .02	57.1	− 0.1	84	16	70	28	29	45	46	45	37	56				2.31	+ 1.4	6	7,725	w.	56	w.	23	14	13	3	4.2	0.0	0.0
Lander	5,372	60	68	24.66	29.95	− .01	56.4	+ 1.2	84	16	71	25	25	42	45	45	35	50				1.31	+ 0.3	5	4,088	sw.	34	sw.	19	14	15	1	3.9	0.0	0.0
Sheridan	3,790	10	47	26.06	29.93		57.5		93	17	75	25	29	40	56	46	37	58				0.16		4	3,369	s.	26	sw.	26	15	10	5	3.7	0.0	0.0
Yellowstone Park	6,200	11	48	23.90	29.96	− .01	50.3	− 3.1	79	16	63	25	26	38	41	41	34	61				1.44	+ 0.4	11	5,776	s.	40	sw.	13	9	15	6	4.9	2.0	0.0
North Platte	2,821	11	51	27.09	29.99	+ .02	64.2	+ 1.0	94	19	80	27	30	48	52	53	47	66				0.83	− 0.7	4	3,966	w.	24	s.	24	14	13	3	3.4	0.0	0.0
Middle Slope.							68.5	+ 0.9													66	2.14	+ 0.2									3.5		
Denver	5,292	106	113	24.76	29.95	− .01	62.5	− 0.2	86	16	76	37	30	49	42	48	37	48				0.06	− 0.8	2	4,896	s.	33	w.	23	18	7	5	3.5	0.0	0.0
Pueblo	4,685	80	86	25.32	29.94	− .02	64.2	− 0.2	91	17	78	34	26	50	47	50	41	51				1.33	+ 0.7	6	4,248	nw.	39	w.	23	15	12	3	3.8	0.0	0.0
Concordia	1,392	50	58	28.52	29.97	− .02	69.7	+ 1.6	95	24	82	31	30	57	45	59	54	67				0.36	− 2.2	7	5,330	s.	37	s.	25	15	13	2	3.7	0.0	0.0
Dodge City	2,509	11	51	27.41	29.98	.00	69.4	+ 1.2	95	14	82	33	30	57	41	58	53	68				3.34	+ 1.6	6	6,690	s.	32	sw.	25	21	4	5	2.4	0.0	0.0
Wichita	1,358	139	158	28.55	29.96	− .07	71.2	+ 1.4	93	24	80	36	30	62	34	62	58	71				4.16	+ 1.0	6	8,275	s.	40	s.	23	17	9	4	3.3	0.0	0.0
Altus	1,410	5					74.6		96	24	86	40	30	63	37							3.12		7					18	3	9		0.0	0.0
Broken Arrow	765	11	52	29.15	29.97		72.8		95	24	83	38	30	63	32	66	64	83				3.06		6	7,770	s.	36	ne.	26	16	9	5	4.1	0.0	0.0
Muskogee	652	4					75.6		98	24	87	37	30	64	39							1.67		6		e.			18	8	4		0.0	0.0
Oklahoma	1,214	10	47	28.71	29.97	− .02	73.8	+ 1.7	95	24	84	37	30	64	30	65	62	76				3.60	+ 0.8	7	7,696	s.	34	s.	25	14	13	3	3.7	0.0	0.0
Southern Slope.							75.1	+ 2.3													66	3.76	+ 1.2									3.2		
Abilene	1,738	10	52	28.17	29.94	− .02	76.6	+ 2.4	96	24	88	42	30	65	31	66	62	72				5.66	+ 2.5	6	6,028	s.	46	ne.	5	19	6	5	3.1	0.0	0.0
Amarillo	3,676	10	49	26.29	29.96	.00	70.8	+ 3.1	91	13	83	42	30	58	38	59	55	69				3.04	+ 0.7	7	7,137	s.	36	sw.	23	15	15	0	3.8	0.0	0.0
Del Rio	944	64	71	28.96	29.92	− .02	81.3	+ 2.4	98	23	92	57	30	70	33							3.79	+ 1.3	4	5,937	se.	48	e.	28	21	7	2	2.6	0.0	0.0
Roswell	3,566	75	85	26.36	29.90	− .02	71.6	+ 1.3	93	19	86	47	30	57	40	58	50	56				2.57	+ 0.3	8	4,715	s.	37	nw.	21	18	10	2	3.1	0.0	0.0
Southern Plateau.							72.7	− 0.9													44	0.53	− 0.3									2.2		
El Paso	3,762	110	133	26.19	29.87	− .01	75.1	+ 2.4	92	28	87	53	30	64	35	58	47	44				0.31	− 1.1	3	7,367	e.	40	ne.	1	18	12	0	3.0	0.0	0.0
Santa Fe	7,013	57	66	23.32	29.80	− .04	60.4	− 0.2	79	18	72	40	26	48	34	46	36	49				0.77	− 0.9	7	5,112	e.	30	sw.	16	15	6	9	4.3	0.0	0.0
Flagstaff	6,908	8	57	23.42	29.90	+ .01	55.4	− 0.1	81	3	71	27	26	40	44	43						0.79		5		w.	40	sw.	24	17	11	2		0.0	0.0
Phoenix	1,108	76	81	28.67	29.80	− .01	80.4	− 1.0	105	2	96	51	26	65	43	62	52	43				0.10	− 0.9	3	3,726	e.	22	se.	29	27	1	2	1.2	0.0	0.0
Yuma	141	9	54	29.69	29.83	+ .05	80.0	− 3.9	106	2	96	55	25	64	45	64	53	50				1.48	+ 1.3	1	2,909	sw.	22	w.	22	28	1	1	0.6	0.0	0.0
Independence	3,957	9	41	25.94	29.92	− .06	67.4	− 1.7	93	2	83	39	25	52	42	49	33	32				T.	− 0.1	0	4,046	s.	33	nw.	23	23	7	0	1.9	0.0	0.0
Middle Plateau.							61.9	− 0.5													43	0.55	− 0.1									3.4		
Reno	4,532	74	81	25.45	29.89	− .06	61.2	+ 1.5	93	2	77	30	24	45	43	47	35	46				0.10	− 0.2	3	5,133	w.	44	w.	23	20	7	3	2.9	0.	0.0
Tonopah	6,090	12	20	24.08	29.90		63.1		86	2	74	30	25	52	29	45	28	29				0.03	− 0.5	1	5,947	se.	33	nw.	22	19	11	0	3.0	T.	0.0
Winnemucca	4,344	18	56	25.58	29.93	.00	60.0	− 0.5	90	3	77	31	24	43	48	46	36	51				0.40	+ 0.1	3	4,857	sw.	33	sw.	23	18	3	9	3.7	T.	0.0
Modena	5,479	10	43	24.62	29.90	− .02	59.0	− 1.2	88	2	76	22	25	42	46	43	27	37				0.22	− 0.9	2	7,550	w.	54	s.	23	19	6	5	3.2	0.	0.0
Salt Lake City	4,360	163	203	25.60	29.91	− .04	64.7	− 0.4	87	16	75	37	25	54	30	50	39	44				1.56	+ 0.7	6	5,554	se.	35	nw.	24	14	9	7	4.2	0.	0.0
Grand Junction	4,602	60	68	25.40	29.94	− .01	64.4	− 2.0	89	15	78	37	26	51	35	52	42	50				0.98	0.0	9	4,587	se.	47	sw.	24	13	13	4	3.7	0.	0.0
Northern Plateau.							60.8	− 0.4													56	1.06	+ 0.3									4.5		
Baker	3,471	48	53	26.40	29.95	− .04	55.8	− 1.2	85	16	70	32	24	42	41	47	39	60				0.53	− 0.2	8	4,230	se.	24	sw.	8	15	8	7	4.0	0.0	0.0
Boise	2,739	78	86	27.10	29.92	− .05	63.2	+ 1.3	92	19	76	40	26	50	41	52	44	52				0.64	+ 0.2	8	2,867	nw.	21	nw.	12	15	6	9	4.2	0.0	0.0
Lewiston	757	40	48	29.10	29.90	− .08	63.0	− 0.5	93	4	77	42	24	50	42							1.25	+ 0.6	12	2,024	e.	28	nw.	30	11	6	13	5.2	0.0	0.0
Pocatello	4,477	60	68	25.46	29.92	− .04	60.0	− 0.7	87	16	72	37	27	48	38	47	38	51				0.92	0.0	5	5,746	se.	30	sw.	5	10	13	7	4.8	T.	0.0
Spokane	1,929	101	110	27.88	29.91	− .07	59.2	+ 0.4	87	4	70	42	28	48	36	50	42	60				1.06	0.0	11	5,493	sw.	32	sw.	12	14	8	8	4.3	0.0	0.0
Walla Walla	991	57	65	28.84	29.91	− .09	63.4	− 2.0	92	3	74	45	15	53	34	53	45	56				1.99	+ 1.1	12	3,419	s.	26	s.	17	14	7	9	4.4	0.0	0.0
North Pacific Coast Region.							58.1	+ 0.4													80	4.52	+ 2.1									6.8		
North Head	211	11	56	29.70	29.92	− .01	55.7	− 0.5	78	29	60	47	23	52	25	53	52	87				5.34	+ 3.5	20	12,507	s.	74	se.	13	3	8	19	7.5	0.0	0.0
Port Angeles	29	8	53	29.90	29.93		53.4		76	1	60	42	3	47	28							2.21	+ 0.4	13	3,269	s.	25	w.	10	9	2	19	6.7	0.0	0.0
Seattle	125	215	250	29.79	29.92	− .09	57.8	− 0.1	81	1	64	48	24	52	25	53	50	77				2.34	+ 0.4	17	7,129	s.	48	s.	14	6	5	19	7.1	0.0	0.0
Tacoma	213	113	120	29.70	29.92	− .10	58.0	+ 0.4	85	1	66	44	29	51	35	54	51	79				3.04	+ 0.6	15	4,422	sw.	28	w.	17	6	6	18	7.2	0.0	0.0
Tatoosh Island	86	7	57	29.78	29.88	− .13	54.5	+ 1.5	67	1	58	48	23	51	13	52	51	90				12.31	+ 6.2	20	11,665	s.	49	e.	28	4	6	20	7.4	0.0	0.0
Yakima	1,071	4					61.0		91	3	76	35	26	46	41							1.18		6		nw.			15	5	10		0.0	0.0
Medford	1,425	4					62.6		97	1	78	41	27	48	48							0.99		7		nw.			13	3	14		0.0	0.0
Portland, Oreg.	13	68	106	29.79	29.94	− .09	61.2	+ 0.6	89	1	69	48	15	53	30	55	51	73				4.16	+ 2.3	14	4,090	sw.	22	sw.	17	5	8	17	6.7	0.0	0.0
Roseburg	510	9	57	29.43	29.98	− .04	61.2	+ 0.7	92	1	72	43	7	50	41	54	50	73				2.27	+ 1.2	13	2,157	nw.	27	sw.	17	10	9	11	5.2	0.0	0.0
Middle Pacific Coast Region.							62.3	− 0.4													67	0.50	− 0.1									3.7		
Eureka	62	73	89	29.97	30.04	+ .03	57.2	+ 2.3	74	28	63	45	9	52	21	54	52	87				2.47	+ 1.4	9	3,713	w.	39	sw.	17	3	10	17	7.0	0.0	0.0
Mount Tamalpais	2,375	11	18	27.53	29.98	+ .04	61.5	+ 0.4	87	2	69	43	8	54	21	51	42	59				0.34	− 0.3	1	11,500	nw.	76	nw.	24	22	5	3	2.7	0.0	0.0
Point Reyes Light	490	7	18	29.44	29.96		55.2	− 0.9	69	28	59	48	7	51	17							0.14		4	16,421	nw.	56	nw.	22	9	7	14	6.2	0.0	0.0
Red Bluff	332	50	56	29.55	29.90	− .03	70.5	− 3.4	100	1	84	44	25	57	40	58	47	48				0.04	− 0.8	1	3,951	se.	29	w.	23	23	6	1	2.3	0.0	0.0
Sacramento	69	106	117	29.86	29.92	+ .03	67.5	− 1.6	98	2	81	45	24	54	39	57	49	58				0.01	− 0.4	1	5,758	s.	25	s.	30	25	5	0	1.4	0.0	0.0
San Francisco	155	208	243	29.80	29.97	+ .03	60.4	+ 1.1	86	28	67	50	6	54	32	56	54	85				0.13	− 0.2	1	8,619	sw.	37	sw.	29	16	8	6	3.7	0.0	0.0
San Jose	141	12	110	29.85	30.00		63.8	− 0.9	92	28	76	43	25	51	41							0.02	− 0.3	1	4,126	nw.	24	w.	23	24	3	3	2.3	0.0	0.0
South Pacific Coast Region.							67.6	0.4													67	0.03	− 0.2									2.3		
Fresno	327	80	98	29.56	29.91	+ .04	72.2	− 2.1	100	2	87	49	25	58	37	56	44	43				T.	− 0.3	0	5,755	nw.	28	nw.	23	27	3	0	0.8	0.0	0.0
Los Angeles	338	150	191	29.57	29.93	+ .05	68.4	− 1.1	89	19	78	55	25	59	26	60	56	73				0.04	0.0	1	3,567	sw.	19	w.	27	20	6	4	2.8	0.0	0.0
San Diego	87	62	70	29.83	29.92	+ .03	66.2	− 0.7	78	19	71	52	25	61	17	61	59	80				0.08	0.0	2	4,444	nw.	21	nw.	18	18	9	3	3.3	0.0	0.0
San Luis Obispo	201	32	40	29.75	29.97	+ .04	63.6	+ 2.1	94	27	77	44	23	50	44	54	49	71				T.	− 0.4	0	3,007	nw.	19	w.	24	22	5	3	2.4	0.0	0.0
West Indies.																																	
San Juan, P. R	82	8	54	29.88	29.97		80.0		90	30	85	69	28	75	21							6.27	− 0.5	23	8,146	e.	33	ne.	17	9	18	3	4.9	0.0	0.0
Panama Canal.																																	
Balboa Heights	118	7	97	29.72	29.84	.00	80.0	+ 0.8	90	15	86	72	9	74	17	75	74	87				9.14	+ 1.2	22	4,464	nw.	30	s.	8	0	13	17	7.6	0.0	0.0
Colon	36	7	97	29.80	29.84	.00	81.4	+ 1.4	92	18	87	74	6	76	18	76	75	83				6.81	− 5.7	10	4,672	w.	23	w.	2	3	14	13	7.0	0.0	0.0
Alaska.																																	
Juneau	80	11	49																														

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1920, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	5	4:10 p. m.	5:15 p. m.	2.43	4:19 p. m.	4:56 p. m.	0.01	0.40	1.06	1.48	1.77	2.03	2.24	2.37	2.41						
		5:55 p. m.	D. N. p. m.	1.05	7:34 p. m.	7:45 p. m.	0.02	0.24	0.58	0.61											
Albany, N. Y.	30			2.51														0.29			
Alpena, Mich.	6			1.37														0.52			
Amarillo, Tex.	4	9:15 p. m.	D. N. p. m.	0.76	9:38 p. m.	9:59 p. m.	0.07	0.15	0.31	0.46	0.55	0.58									
	5–6	D. N. p. m.	D. N. a. m.	1.65	12:25 a. m.	12:50 a. m.	0.14	0.17	0.65	0.95	1.22	1.30									
Anniston, Ala.	2	5:40 p. m.	10:15 p. m.	2.65	6:07 p. m.	7:06 p. m.	0.01	0.09	0.44	0.88	1.20	1.38	1.60	1.72	1.84	1.93	2.04	2.14			
	3	3:02 p. m.	3:35 p. m.	0.66	3:02 p. m.	3:29 p. m.	0.00	0.15	0.20	0.33	0.52	0.57	0.65								
	9	2:07 p. m.	3:05 p. m.	0.85	2:21 p. m.	2:36 p. m.	0.03	0.19	0.23	0.43	0.69	0.78									
Asheville, N. C.	27	4:50 p. m.	7:30 p. m.	1.28	5:09 p. m.	5:49 p. m.	0.09	0.15	0.36	0.57	0.72	0.77	0.80	0.89	0.98						
Atlanta, Ga.	6	11:13 a. m.	11:50 a. m.	0.52	11:33 a. m.	11:46 a. m.	0.01	0.18	0.40	0.51											
	8	9:50 a. m.	10:55 a. m.	0.77	10:07 a. m.	10:26 a. m.	0.01	0.10	0.37	0.66	0.69										
	24	4:55 p. m.	9:15 p. m.	1.22	7:04 p. m.	7:29 p. m.	0.50	0.09	0.22	0.32	0.47	0.55									
Atlantic City, N. J.	30			1.06														0.33			
Augusta, Ga.	8	3:40 p. m.	6:00 p. m.	0.80	4:32 p. m.	4:57 p. m.	0.11	0.22	0.32	0.42	0.53	0.62									
	29–30	11:45 a. m.	9:09 a. m.	4.03	11:51 a. m.	12:38 p. m.	0.01	0.05	0.16	0.26	0.40	0.52	0.62	0.92	1.14	1.20	1.24				
					1:50 p. m.	2:49 p. m.	1.41	0.20	0.36	0.39	0.41	0.50	0.56	0.80	0.94	1.06	1.20	1.39			
Baker, Oreg.	23			0.25														0.12			
Baltimore, Md.	27			0.52														0.51			
Bentonville, Ark.	8–9			1.12														0.49			
Binghamton, N. Y.	27–28	9:45 p. m.	D. N. a. m.	1.27	10:31 p. m.	11:04 p. m.	0.06	0.07	0.28	0.42	0.56	0.66	0.84	0.94							
Birmingham, Ala.	2	2:23 p. m.	D. N. p. m.	2.73	2:32 p. m.	3:54 p. m.	0.01	0.12	0.15	0.22	0.31	0.49	0.72	0.90	0.99	1.15	1.28	1.77	2.29	2.40	
	16	5:00 a. m.	6:15 a. m.	0.65	5:30 a. m.	5:57 a. m.	0.02	0.05	0.17	0.41	0.50	0.58	0.62								
Bismarck, N. Dak.	23			0.65														0.42			
Block Island, R. I.	10			0.28														0.21			
Boise, Idaho.	23			0.34														0.11			
Boston, Mass.	30			0.50														0.21			
Buffalo, N. Y.	16			0.21														0.20			
Burlington, Vt.	7	2:10 p. m.	3:20 p. m.	0.63	2:18 p. m.	2:35 p. m.	0.02	0.13	0.33	0.45	0.50										
Cairo, Ill.	10	3:33 p. m.	5:16 p. m.	0.68	4:36 p. m.	4:48 p. m.	0.05	0.22	0.54	0.62											
Canton, N. Y.	28			1.12														0.58			
Charles City, Iowa.	10	5:40 p. m.	7:23 p. m.	0.79	6:28 p. m.	6:57 p. m.	0.10	0.08	0.20	0.35	0.47	0.53									
Charleston, S. C.	8–9	9:23 p. m.	D. N. a. m.	0.86	9:28 p. m.	9:40 p. m.	0.01	0.23	0.65	0.70											
	15	D. N. a. m.	8:40 a. m.	3.13	4:43 a. m.	5:25 a. m.	0.27	0.26	0.53	0.85	1.23	1.58	1.88	2.15	2.27	2.31					
Charlotte, N. C.	16	8:53 p. m.	11:10 p. m.	0.65	9:44 p. m.	10:06 p. m.	0.02	0.18	0.32	0.46	0.53	0.57									
	27	4:28 p. m.	8:50 p. m.	0.86	6:21 p. m.	6:42 p. m.	0.14	0.10	0.26	0.38	0.56	0.58									
Chattanooga, Tenn.	9	12:18 p. m.	2:25 p. m.	0.83	12:24 p. m.	12:47 p. m.	T.	0.22	0.37	0.57	0.64	0.73									
	10	6:43 a. m.	9:02 a. m.	0.65	7:20 a. m.	7:30 a. m.	T.	0.40	0.63												
Cheyenne, Wyo.	6	12:05 p. m.	3:12 p. m.	1.59	12:09 p. m.	1:10 p. m.	0.01	0.08	0.11	0.20	0.31	0.41	0.53	0.62	0.75	0.88	1.07	1.35	1.42		
Chicago, Ill.	5	4:45 p. m.	7:40 p. m.	1.62	5:47 p. m.	6:32 p. m.	0.13	0.06	0.10	0.17	0.34	0.53	0.70	0.83	1.22	1.41					
Cincinnati, Ohio.	27			0.58														0.43			
Cleveland, Ohio.	30			0.97														0.41			
Columbia, Mo.	10	12:06 p. m.	12:50 p. m.	0.76	12:12 p. m.	12:29 p. m.	0.01	0.17	0.43	0.69	0.73										
	15	D. N. a. m.	7:30 a. m.	0.98	6:45 a. m.	7:10 a. m.	0.39	0.10	0.35	0.43	0.49	0.57									
	26	5:28 p. m.	6:33 p. m.	0.80	5:59 p. m.	6:25 p. m.	0.03	0.09	0.20	0.42	0.57	0.75	0.76								
Columbia, S. C.	8	1:35 p. m.	3:00 p. m.	0.84	1:44 p. m.	2:25 p. m.	0.02	0.14	0.23	0.36	0.44	0.50	0.59	0.68	0.75	0.80					
	29–30	2:00 p. m.	11:00 a. m.	2.32	2:18 p. m.	2:58 p. m.	0.02	0.16	0.33	0.39	0.52	0.76	1.04	1.32	1.42						
Columbus, Ohio.	5			0.93														0.54			
Concord, N. H.	13			1.88														0.72			
Concordia, Kans.	25			0.17														0.14			
Corpus Christi, Tex.	4			T.														T.			
Dallas, Tex.	6			0.66														0.51			
Davenport, Iowa.	26			1.40														0.55			
Dayton, Ohio.	4–5	D. N. p. m.	4:30 a. m.	1.21	12:36 a. m.	1:00 a. m.	0.07	0.16	0.42	0.59	0.78	0.88									
Del Rio, Tex.	17	7:40 p. m.	9:50 p. m.	1.80	9:11 p. m.	9:40 p. m.	0.44	0.27	0.52	0.69	0.99	1.25	1.36								
	28	4:40 p. m.	5:50 p. m.	0.81	4:47 p. m.	5:17 p. m.	0.01	0.25	0.43	0.48	0.61	0.69	0.76								
Denver, Colo.	7			0.05														0.04			
Des Moines, Iowa.	4–5	6:15 p. m.	D. N. a. m.	1.75	8:49 p. m.	9:05 p. m.	0.11	0.28	0.68	0.97	0.99										
Detroit, Mich.	5			0.60														0.29			
Devils Lake, N. Dak.	19	D. N. a. m.	D. N. a. m.	3.80	12:42 a. m.	2:04 a. m.	0.04	0.07	0.36	0.50	0.54	0.62	0.70	0.80	0.92	0.98	1.05	1.20	1.55	1.59	
					2:35 a. m.	3:35 a. m.	1.67	0.05	0.13	0.30	0.70	0.91	1.04	1.16	1.27	1.48	1.71	1.91			
Dodge City, Kans.	6	5:10 a. m.	6:55 a. m.	0.71	5:53 a. m.	6:15 a. m.	0.14	0.10	0.17	0.28	0.49	0.53									
Drexel, Nebr.	25			0.71														0.36			
Dubuque, Iowa.	8–9			1.05														0.43			
Duluth, Minn.	10			0.80														0.39			
Eastport, Me.	18			0.71														0.33			
Elkins, W. Va.	27	7:10 p. m.	D. N. p. m.	1.27	8:50 p. m.	9:25 p. m.	0.07	0.23	0.42	0.52	0.57	0.62	0.64	0.71	0.78	0.82	0.86	1.00	1.13		
Ellendale, N. Dak.	10			0.38														0.38			
El Paso, Tex.	1			0.11														0.11			
Erie, Pa.	9			0.34														0.33			
Escanaba, Mich.	15	8:15 a. m.	12:30 p. m.	1.61	9:29 a. m.	10:13 a. m.	0.10	0.14	0.19	0.28	0.37	0.41	0.57	0.74	0.96	1.19					
Eureka, Calif.	23			0.76														0.44			
Evansville, Ind.	9	12:30 a. m.	D. N. a. m.	1.33	12:30 a. m.	1:05 a. m.	0.00	0.10	0.12	0.26	0.47	0.74	0.88	0.95							
Flagstaff, Ariz.	4–5			0.60														(*)			
Fort Smith, Ark.	6	11:06 a. m.	12:42 p. m.	0.86	11:57 a. m.	12:22 p. m.	0.06	0.07	0.18	0.36	0.59	0.72									
Fort Wayne, Ind.	26	11:45 a. m.	1:23 p. m.	0.77	11:59 a. m.	12:23 p. m.	0.02	0.18	0.33	0.57	0.69	0.73									
Fort Worth, Tex.	4			0.68														0.56			
Fresno, Calif.	17			T.														T.			
Galveston, Tex.	3	D. N. a. m.	D. N. a. m.	0.85	1:10 a. m.	1:24 a. m.	0.05	0.20	0.43	0.50											
Grand Haven, Mich.	9			1.00														(*)			
Grand Junction, Colo.	6			0.31														0.16			
Grand Rapids, Mich.	8–9	11:20 p. m.	11:30 a. m.	2.25	7:33 a. m.	8:41 a. m.	1.04	0.08	0.18	0.25	0.27	0.36	0.51	0.51	0.52	0.54	0.61	0.71	1.01		
Green Bay, Wis.	26			0.23														0.23			
Greenville, S. C.	30			0.58														0.50			
Hannibal, Mo.	10	6:55 p. m.	D. N. p. m.	1.56	7:52 p. m.	8:12 p. m.	0.01	0.40	0.46	0.57	0.67										
					8:59 p. m.	9:36 p. m.	0.84	0.14	0.31	0.34	0.39	0.39	0.44	0.56	0.60						
Harrisburg, Pa.	30	D. N. a. m.	5:50 p. m.	2.00	4:40 a. m.	5:35 a. m.	0.23	0.07	0.13	0.20	0.26	0.39	0.46	0.52	0.60	0.67	0.76	0.84			
Hartford, Conn.	12	7:30 a. m.	10:18 a. m.	1.15	9:08 a. m.	9:33 a. m.	0.02	0.16	0.52	0.75	1.01	1.06									
	30–1	D. N. a. m.	D. N. a. m.	4.60	10:04 p. m.	10:32 p. m.	3.84	0.08	0.25	0.40	0.49	0.61	0.69								
Hatteras, N. C.	23	D. N. a. m.	7:10 a. m.	2.18	4:21 a. m.	4:40 a. m.	0.08	0.13	0.25	0.46	0.70										
					6:09 a. m.	6:40 a. m.	1.18	0.19	0.36	0.69	0.77	0.85	0.97	0.99							
	25	D. N. p. m.	D. N. p. m.	0.61	9:56 p. m.	10:18 p. m.	0.03	0.23	0.37	0.39	0.48	0.52									
	30	12:22 p. m.	8:15 p. m.	2.04	12:51 p. m.	1:44 p. m.	0.13	0.10	0.17	0.22	0.32	0.53	0.89	0.95	1.02	1.04	1.12	1.25			
Havre, Mont.	18			0.05														0.05			
Helena, Mont.	24			1.20														0.29			
Houghton, Mich.	28			0.45														0.25			
Houston, Tex.	2	5:35 a. m.	12:10 p. m.	1.68	5:37 a. m.	6:37 a. m.	0.01	0.24	0.39	0.55	0.68	0.78	0.96	1.08	1.15	1.21	1.33	1.54			
	25	1:33 p. m.	4:50 p. m.	2.02	1:49 p. m.	2:26 p. m.	0.01	0.27	0.61	0.79	0.91	1.07	1.27	1.43	1.49						
Huron, S. Dak.	23	7:03 p. m.	D. N. p. m.	1.17	7:08 p. m.	7:23 p. m.	0.01	0.30	0.55	0.74											

* Self-register not in sue.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1920, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Independence, Calif.	3			T														T			
Indianapolis, Ind.	11			0.56														0.48			
Iola, Kans.	3			1.09														0.69			
Jacksonville, Fla.	2	4:10 p. m.	8:20 p. m.	1.84	4:10 p. m.	5:11 p. m.	0.00	0.14	0.38	0.64	0.78	1.01	1.11	1.19	1.38	1.52	1.63	1.75	1.79		
Kalispell, Mont.	12			0.19														0.09			
Kansas City, Mo.	7			0.97														0.40			
Keokuk, Iowa	11	5:02 p. m.	6:21 p. m.	0.58	5:16 p. m.	5:41 p. m.	0.02	0.11	0.29	0.39	0.45	0.52									
	16	8:52 a. m.	9:50 a. m.	0.72	8:52 a. m.	9.33 a. m.	0.00	0.07	0.18	0.22	0.29	0.32	0.40	0.55	0.70	0.72					
	24	8:29 a. m.	9:35 a. m.	0.56	8:31 a. m.	8:42 a. m.	0.01	0.28	0.52	0.55											
Key West, Fla.	24–25	9:11 p. m.	6:50 a. m.	3.01	9:31 p. m.	10:11 p. m.	0.03	0.20	0.46	0.51	0.80	1.16	1.50	1.84	2.06						
	25–26	7:30 a. m.	6:35 p. m.	4.40	1:09 p. m.	1:46 p. m.	0.43	0.11	0.17	0.33	0.42	0.49	0.54	0.63	0.67						
					3:41 a. m.	4:07 a. m.	1.83	0.09	0.23	0.38	0.61	0.74	0.78								
	27	8:50 a. m.	9:55 a. m.	0.84	9:23 a. m.	9:51 a. m.	0.02	0.14	0.16	0.36	0.69	0.77	0.82								
Knoxville, Tenn.	9			0.48														0.40			
La Crosse, Wis.	9			0.25														0.21			
Lander, Wyo.	6–7	9:04 p. m.	D.N.a.m.	1.17	9:59 p. m.	10:45 p. m.	0.09	0.10	0.17	0.29	0.41	0.48	0.52	0.56	0.62	0.68	0.70				
Lansing, Mich.	15	6:30 p. m.	7:30 p. m.	0.56	6:57 p. m.	7:13 p. m.	0.02	0.11	0.39	0.53	0.54										
Lewiston, Idaho.	12–13			0.57														0.09			
Lexington, Ky.	12	D.N.a.m.	D.N.a.m.	2.31	12:15 a. m.	1:25 a. m.	0.01	0.17	0.22	0.40	0.49	0.52	0.52	0.52	0.52	0.59	0.74	0.87	1.25		
					1:56 a. m.	2:33 a. m.	1.35	0.12	0.25	0.26	0.27	0.34	0.56	0.85	0.93						
Lincoln, Nebr.	1			0.35														0.35			
Little Rock, Ark.	9	D.N.a.m.	7:15 a. m.	0.74	4:53 a. m.	5:17 a. m.	0.02	0.12	0.16	0.39	0.58	0.63									
Los Angeles, Calif.	24			0.04														0.04			
Louisville, Ky.	15			0.34														0.32			
Ludington, Mich.	26			0.56														0.50			
Lynchburg, Va.	23	7:00 p. m.	8:10 p. m.	0.59	7:31 p. m.	7:59 p. m.	0.02	0.08	0.19	0.25	0.35	0.47	0.56								
	6	5:07 p. m.	6:06 p. m.	0.87	5:22 p. m.	5:43 p. m.	0.02	0.24	0.36	0.66	0.81	0.84									
	17	4:00 a. m.	5:00 a. m.	0.91	4:08 a. m.	4:28 a. m.	0.01	0.17	0.38	0.63	0.79										
Macon, Ga.	27	7:36 p. m.	8:35 p. m.	0.62	7:40 p. m.	8:08 p. m.	0.01	0.28	0.32	0.36	0.41	0.49	0.53								
	29	1:48 p. m.	3:20 p. m.	1.54	2:10 p.m.	2:51 p. m.	0.08	0.31	0.53	0.76	0.90	1.00	1.07	1.17	1.39	1.42					
Madison, Wis.	9			0.63														0.37			
Marquette, Mich.	15			0.80														0.64			
	1	12:40 p. m.	6:20 p. m.	2.70	2:26 p. m.	3:02 p. m.	0.72	0.15	0.36	0.52	0.67	0.82	0.98	1.12	1.14						
					4:08 p. m.	4:40 p. m.	1.89	0.09	0.24	0.40	0.51	0.64	0.71	0.74							
	7	D.N.a.m.	10:30 a. m.	3.89	7:40 a. m.	9:30 a. m.	0.75	0.15	0.19	0.22	0.33	0.54	0.82	1.25	1.41	1.52	1.61	1.70	1.93	2.50	2.84
Memphis, Tenn.	8	2:28 p. m.	5:40 p. m.	1.67	3:36 p. m.	4:34 p. m.	0.08	0.14	0.47	0.64	0.73	0.91	1.15	1.23	1.23	1.24	1.27	1.52			
					5:28 a. m.	5:55 a. m.	0.15	0.12	0.30	0.39	0.46	0.58	0.62								
	9	D.N.a.m.	8:45 a. m.	1.95	6:53 a. m.	7:18 a. m.	0.88	0.18	0.36	0.64	0.73	0.81									
Meridian, Miss.	4–5	D.N.p.m.	D.N.a.m.	1.66	10:37 p. m.	11:12 p. m.	0.11	0.24	0.46	0.58	0.89	1.05	1.11	1.22							
Miami, Fla.	4	2:46 p. m.	5:25 p. m.	0.61	3:03 p. m.	3:26 p. m.	0.04	0.07	0.23	0.33	0.45	0.52									
	28	8:35 a. m.	10:45 a. m.	1.19	9:03 a. m.	10:02 a. m.	0.02	0.18	0.38	0.53	0.66	0.72	0.73	0.74	0.74	0.74	0.82	1.13			
Milwaukee, Wis.	5			0.98														0.55			
Minneapolis, Minn.	10			0.36														0.36			
Mobile, Ala.	21–22	9:30 p. m.	4:05 p. m.	5.40	7:01 a. m.	7:37 a. m.	1.28	0.11	0.21	0.38	0.65	1.03	1.26	1.37	1.40						
					10:05 a. m.	11:16 a. m.	3.44	0.21	0.38	0.44	0.46	0.50	0.56	0.59	0.65	0.68	0.75	0.96	1.18		
Modena, Utah	5			0.21														0.21			
Montgomery, Ala.	5	5:30 p. m.	6:40 p. m.	1.50	5:37 p. m.	6:27 p. m.	0.06	0.21	0.68	0.90	0.96	0.97	0.97	1.00	1.03	1.20	1.44				
	23	12:20 p. m.	5:30 p. m.	1.94	1:38 p. m.	2:17 p. m.	0.39	0.15	0.25	0.34	0.53	0.81	0.98	1.06	1.17						
Moorhead, Minn.	10			0.56														0.55			
Mount Tamalpais, Calif.	23			0.34														0.23			
Nantucket, Mass.	12			0.88														0.61			
Nashville, Tenn.	12	7:55 p. m.	8:45 p. m.	1.31	8:00 p. m.	8:19 p. m.	0.01	0.51	1.06	1.18	1.25										
	15	1:55 p. m.	2:40 p. m.	0.73	2:10 p. m.	2:24 p. m.	0.07	0.10	0.40	0.63											
New Haven, Conn.	28	2:55 p. m.	7:00 p. m.	1.02	4:17 p. m.	4:52 p. m.	0.15	0.09	0.15	0.18	0.22	0.36	0.54	0.68							
New Orleans, La.	21	11:57 a. m.	1:40 p. m.	0.70	12:00 noon.	12:21 p. m.	0.01	0.27	0.43	0.53	0.64	0.66									
	21–22	4:35 p. m.	12:20 a. m.	2.55	6:40 p. m.	7:08 p. m.	0.89	0.12	0.30	0.39	0.58	0.69	0.73								
	22	4:50 p. m.	5:47 p. m.	0.71	5:10 p. m.	5:37 p. m.	0.06	0.06	0.10	0.23	0.45	0.57	0.65								
New York, N. Y.	10			0.90														0.68			
Norfolk, Va.	30			1.68														0.60			
Northfield, Vt.	30			2.31														0.45			
North Head, Wash.	24			0.80														0.37			
North Platte, Nebr.	3	1:57 p. m.	2:20 p. m.	0.72	1:57 p. m.	2:04 p. m.	0.00	0.58	0.65												
Oklahoma, Okla.	3–4	11:05 p. m.	D.N.a.m.	1.00	12:05 a. m.	12:29 a. m.	0.12	0.13	0.29	0.41	0.54	0.63									
Omaha, Nebr.	23			0.33														0.27			
Oswego, N. Y.	11	9:10 p. m.	10:10 p. m.	0.75	9:14 p. m.	9:44 p. m.	0.01	0.07	0.20	0.32	0.39	0.50	0.64								
Palestine, Tex.	6–7	6:30 p. m.	D.N.a.m.	2.58	6:33 p. m.	6:45 p. m.	0.01	0.32	0.71	0.73											
					7:30 p. m.	8:05 p. m.	0.79	0.24	0.45	0.51	0.53	0.67	0.86	0.99							
Parkersburg, W. Va.	9	3:27 p. m.	11:12 p. m.	1.32	7:16 p. m.	7:48 p. m.	0.09	0.12	0.37	0.56	0.62	0.71	0.77	0.82							
	27	3:17 p. m.	4:45 p. m.	0.56	3:56 p. m.	4:26 p. m.	0.05	0.13	0.26	0.31	0.41	0.41	0.51								
	2	5:10 p. m.	5:57 p. m.	0.54	5:25 p. m.	5:43 p. m.	0.01	0.24	0.33	0.43	0.52										
	4	11:25 a. m.	1:40 p. m.	1.59	11:33 a. m.	12:40 p. m.	0.05	0.17	0.38	0.57	0.68	0.75	0.78	0.80	0.87	0.96	1.02	1.26	1.50		
	5	10:12 a. m.	12:35 p. m.	1.77	10:57 a. m.	11:28 a. m.	0.01	0.27	0.82	1.25	1.59	1.67	1.72	1.75							
Pensacola, Fla.					12:58 p. m.	1:48 p. m.	0.68	0.13	0.29	0.38	0.40	0.44	0.60	0.66	0.68	0.73	0.90				
	22	7:30 a. m.	8:45 p. m.	3.15	1:48 p. m.	2:38 p. m.	.....	1.05	1.19	1.28	1.38	1.45	1.50	1.52	1.53	1.56	1.66				
					2:38 p. m.	3:07 p. m.	.....	1.70	1.75	1.79	1.88	1.98	2.05								
	23	D.N.a.m.	5:10 p. m.	4.20	10:16 a. m.	12:03 p. m.	1.07	0.16	0.34	0.55	0.69	0.83	0.89	0.92	0.99	1.04	1.05	1.10	1.33	2.26	2.56
Peoria, Ill.	26			0.49														0.35			
Philadelphia, Pa.	10			0.70														0.66			
Phoenix, Ariz.	4			0.56														0.06			
Pierre, S. Dak.	23			0.33														0.21			
Pittsburgh, Pa.	9	6:25 p. m.	D.N.p.m.	1.11	6:54 p. m.	7:22 p. m.	0.04	0.09	0.20	0.21	0.31	0.80	0.89								
Pocatello, Idaho.	6			0.21														0.19			
Point Reyes Light, Calif.	20			0.05														0.03			
Port Angeles, Wash.	11			0.93														0.25			
Port Huron, Mich.	30			1.56														0.30			
Portland, Me.	13	11:30 a. m.	9:32 p. m.	2.59	1:05 p. m.	1:56 p. m.	0.25	0.05	0.21	0.31	0.40	0.47	0.57	0.67	0.72	0.76	0.82	0.90			
Portland, Oreg.	24			0.58														0.33			
Providence, R. I.	12			0.34														0.27			
Pueblo, Colo.	1			0.54														0.42			
Raleigh, N. C.	23	8:40 a. m.	10:45 a. m.	0.86	9:27 a. m.	9:37 a. m.	0.13	0.23	0.64												
Rapid City, S. Dak.	23			0.43														0.19			
Reading, Pa.	30			1.89														0.45			
Red Bluff, Calif.	23			0.04														0.04			
Reno, Nev.	8			0.03														0.02			
Richmond, Va.	28			0.50														0.37			
Rochester, N. Y.	27			0.25														0.25			
Roseburg, Oreg.	24			0.56														0.15			
Roswell, N. Mex.	13	1:37 p. m.	2:23 p. m.	0.57	1:50 p. m.	2:16 p. m.	0.01	0.12	0.19	0.30	0.45	0.54	0.56								

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1920, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Sacramento, Calif.	20			0.01														0.01			
Saginaw, Mich.	26			0.51														0.51			
St. Joseph, Mo.	2	3:01 p. m.	4:55 p. m.	0.89	3:05 p. m.	3:32 p. m.	0.01	0.14	0.44	0.57	0.70	0.79	0.81								
	10	7:33 a. m.	9:23 a. m.	0.92	8:39 a. m.	9:02 a. m.	0.04	0.10	0.24	0.43	0.67	0.86									
St. Louis, Mo.	8	9:30 a. m.	12:22 p. m.	1.66	10:57 a. m.	11:13 a. m.	0.57	0.23	0.64	0.81	0.84										
		5:01 p. m.	5:50 p. m.	1.14	5:17 p. m.	5:43 p. m.	0.08	0.14	0.22	0.42	0.82	0.99	1.06								
	11	8:26 p. m.	10:25 p. m.	1.13	8:28 p. m.	8:55 p. m.	0.01	0.13	0.36	0.56	0.70	0.80	0.85								
St. Paul, Minn.	10–11			0.30														0.30			
Salt Lake City, Utah	5–6			0.39														0.38			
San Antonio, Tex.	4			0.15														0.15			
San Diego, Calif.	15			0.05														0.05			
Sand Key, Fla.	17	8:36 p. m.	9:35 p. m.	2.02	8:39 p. m.	9:16 p. m.	0.01	0.34	0.65	0.90	1.30	1.66	1.88	1.97	2.00						
	24–26	11:15 p. m.	11:30 a. m.	5.02	11:43 p. m.	1:24 a. m.	1.70	0.16	0.37	0.49	0.60	0.68	0.74	0.77	0.80	0.82	0.87	1.15	1.46	1.72	
Sandusky, Ohio	9	7:15 p. m.	9:00 p. m.	0.84	8:27 p. m.	8:38 p. m.	0.26	0.31	0.54	0.58											
Sandy Hook, N. J.	30			1.19														0.25			
San Francisco, Calif.	23			0.13														0.11			
San Jose, Calif.	23			0.02														0.02			
San Luis Obispo, Calif.	23			T.														T.			
Santa Fe, N. Mex.	20			0.21														0.21			
Sault Ste. Marie, Mich.	15	11:58 a. m.	6:58 p. m.	1.81	12:06 p. m.	12:22 p. m.	T.	0.19	0.41	0.56	0.61										
Savannah, Ga.	4	3:40 p. m.	5:45 p. m.	1.12	3:40 p. m.	4:31 p. m.	0.00	0.28	0.31	0.33	0.38	0.50	0.53	0.58	0.75	0.97	1.04	1.09			
	9	5:05 p. m.	6:15 p. m.	0.59	5:35 p. m.	5:50 p. m.	0.03	0.18	0.38	0.55											
Scranton, Pa.	27			0.57														0.53			
Seattle, Wash.	12			0.35														0.17			
Sheridan, Wyo.	7			0.13														0.09			
Shreveport, La.	22			0.79														0.31			
Sioux City, Iowa	23			0.92														0.48			
Spokane, Wash.	12			0.29														0.07			
Springfield, Ill.	15	6:23 a. m.	9:14 a. m.	0.89	8:01 a. m.	8:25 a. m.	0.28	0.19	0.39	0.44	0.53	0.58									
Springfield, Mo.	23–24	9:54 p. m.	D. N. a. m.	1.39	10:27 p. m.	10:45 p. m.	0.01	0.24	0.32	0.57	0.62										
Syracuse, N. Y.	11	8:15 p. m.	D. N. p. m.	1.26	8:17 p. m.	8:36 p. m.	0.01	0.08	0.30	0.46	0.58										
	12	3:20 p. m.	4:20 p. m.	0.58	3:47 p. m.	4:07 p. m.	0.01	0.09	0.14	0.37	0.55										
Tacoma, Wash.	30			0.39														0.29			
Tampa, Fla.	23	6:10 p. m.	9:05 p. m.	1.16	6:15 p. m.	6:33 p. m.	0.01	0.23	0.48	0.74	0.86										
	30	D. N. a. m.	6:05 a. m.	0.60	4:24 a. m.	4:40 a. m.	0.06	0.11	0.22	0.45	0.51										
		7:07 a. m.	10:45 a. m.	1.42	8:20 a. m.	9:47 a. m.	0.22	0.07	0.11	0.15	0.20	0.25	0.32	0.35	0.42	0.50	0.58	0.72	1.06	1.18	
Tatoosh Island, Wash.	26			1.02														0.30			
Taylor, Tex.	28			0.37														0.37			
Terre Haute, Ind.	27			1.15														0.49			
Thomasville, Ga.	2	3:44 p. m.	9:14 p. m.	1.76	4:38 p. m.	4:58 p. m.	0.32	0.11	0.20	0.42	0.54										
	7	5:25 p. m.	7:37 p. m.	1.09	6:27 p. m.	6:46 p. m.	0.26	0.25	0.47	0.60	0.71	0.77									
	23	4:06 p. m.	8:32 p. m.	1.39	4:24 p. m.	5:09 p. m.	0.02	0.17	0.26	0.37	0.48	0.55	0.68	1.02	1.13	1.24					
Toledo, Ohio	9	4:34 p. m.	5:55 p. m.	0.89	5:27 p. m.	5:45 p. m.	0.36	0.07	0.17	0.36	0.52										
Tonopah, Nev.	16			0.03														0.03			
Topeka, Kans.	2	2:45 p. m.	4:00 p. m.	0.70	2:58 p. m.	3:17 p. m.	0.01	0.27	0.45	0.59	0.65										
	3	2:00 p. m.	5:15 p. m.	1.27	2:21 p. m.	2:48 p. m.	0.05	0.15	0.44	0.71	0.80	0.88	0.93								
Trenton, N. J.	30			1.41														0.39			
Valentine, Nebr.	20–21	7:10 p. m.	3:20 a. m.	1.88	12:47 a. m.	1:22 a. m.	0.80	0.09	0.26	0.32	0.44	0.52	0.58	0.72							
Vicksburg, Miss.	1	12:51 p. m.	2:10 p. m.	1.86	12:55 p. m.	1:26 p. m.	0.01	0.34	0.76	1.03	1.50	1.71	1.79	1.83							
	2	7:45 p. m.	9:20 p. m.	0.75	8:00 p. m.	8:25 p. m.	0.01	0.08	0.39	0.55	0.63	0.68									
Walla Walla, Wash.	12			0.84														0.26			
Washington, D. C.	9–10	11:30 p. m.	1:30 a. m.	1.21	12:10 a. m.	12:35 a. m.	0.04	0.14	0.29	0.57	0.85	1.04									
Wausau, Wis.	9			0.53														0.21			
Wichita, Kans.	3	5:15 p. m.	D. N. p. m.	0.93	5:28 p. m.	5:52 p. m.	0.02	0.09	0.16	0.32	0.47	0.60									
	26	D. N. a. m.	D. N. a. m.	1.38	12:55 a. m.	1:20 a. m.	0.03	0.05	0.12	0.16	0.30	0.56									
Williston, N. Dak.	23			0.47														0.23			
Wilmington, N. C.																					
Winnemucca, Nev.	22			0.22														0.19			
Wytheville, Va.	25	1:00 p. m.	4:35 p. m.	0.90	1:02 p. m.	1:44 p. m.	0.01	0.05	0.22	0.31	0.35	0.46	0.63	0.68	0.74	0.78					
	27	6:10 p. m.	6:50 p. m.	0.89	6:16 p. m.	6:45 p. m.	T.	0.21	0.29	0.30	0.31	0.64	0.89								
Yankton, S. Dak.	25			0.53														0.51			
Yellowstone Park, Wyo.	5			0.57														0.31			

TABLE III.—*Data furnished by the Canadian Meteorological Service, September, 1920.*

Stations.	Altitude above mean sea level Jan. 1, 1919.	Pressure.			Temperature of the air.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min.÷2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125	29.76	29.90	−0.07	53.5	−0.5	60.7	46.3	73	36	5.72	+2.01	0.0
Sydney, C. B. I.	48	29.91	29.96	− .07	58.1	+1.6	66.1	50.1	82	38	3.66	+0.38	0.0
Halifax, N. S.	88	29.84	29.94	− .10	58.9	+1.3	66.9	51.0	81	36	1.72	−1.99	0.0
Yarmouth, N. S.	65	29.88	29.95	− .10	57.6	+1.5	64.2	50.7	76	37	3.75	+0.30	0.0
Charlottetown, P. E. I.	38	29.88	29.92	− .09	57.7	+0.4	63.8	51.6	80	41	3.73	+0.33	0.0
Chatham, N. B.	28	29.92	29.95	− .05	55.9	+0.5	63.5	48.4	86	34	6.82	+4.11	0.0
Father Point, Que.	20	29.90	29.92	− .06	49.4	−1.0	56.4	42.4	72	34	1.60	−1.53	0.0
Quebec, Que.	296	29.65	29.97	− .04	56.7	+1.6	64.4	49.0	78	33	3.89	+0.22	0.0
Montreal, Que.	187	29.76	29.96	− .08	60.4	+2.0	68.3	52.6	83	37	4.29	+0.99	0.0
Stonecliffe, Ont.	489	29.37	29.98	− .05	51.6	−4.1	72.1	31.0	90	16	1.94	−1.34	0.0
Ottawa, Ont.	236	29.74	30.00	− .04	61.8	+4.4	73.2	50.4	90	32	4.06	+1.37	0.0
Kingston, Ont.	285	29.69	30.00	− .04	62.8	+2.8	70.9	54.8	81	36	4.62	+1.82	0.0
Toronto, Ont.	379	29.60	30.00	− .06	63.8	+4.8	74.8	52.8	87	37	1.75	−1.50	0.0
Cochrane, Ont.	930												
White River, Ont.	1,244	28.66	29.97	− .01	53.5	+3.2	67.6	39.5	81	16	1.93	−0.84	0.0
Port Stanley, Ont.	592	29.39	30.03	− .03	61.3	+1.8	70.6	51.9	79	38	1.08	−1.65	0.0
Southampton, Ont.	656	29.29			60.6	+3.1	70.0	51.2	85	32	1.81	−1.13	0.0
Parry Sound, Ont.	688	29.34	30.02	− .01	61.0	+5.0	72.3	49.8	87	31	1.82	−1.85	0.0
Port Arthur, Ont.	644	29.27	29.98	.00	58.1	+5.9	67.7	48.6	81	28	1.70	−1.78	0.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.09	29.89	− .05	55.5	+5.0	66.8	44.2	78	29	3.30	+1.94	0.0
Le Pas, Man.	860												
Qu'Appelle, Sask.	2,115	27.61	29.83	− .09	55.6	+4.5	68.6	42.7	86	23	2.68	+1.35	0.0
Medicine Hat, Alb.	2,144	27.51	29.74	− .18	59.9	+4.9	74.4	45.4	86	29	0.00	−1.18	0.0
Moose Jaw, Sask.	1,759												
Swift Current, Sask.	2,392	27.27	29.85	− .07	57.3	+4.2	71.6	43.0	90	26	0.99	−0.23	0.0
Calgary, Alb.	3,428	26.30	29.84	− .08	52.8	+3.0	69.6	36.1	86	28	0.33	−1.03	0.0
Banff, Alb.	4,521	25.28	29.77	− .16	48.1	+2.3	61.0	35.3	78	27	1.76	+0.09	0.0
Edmonton, Alb.	2,150	27.51	29.77	− .13	50.1	+0.8	63.7	36.5	80	24	1.31	−0.02	0.0
Prince Albert, Sask.	1,450	28.27	29.84	− .06	54.9	+6.5	68.8	41.0	81	28	1.91	+0.63	0.0
Battleford, Sask.	1,592	28.07	29.79	− .11	54.3	+2.5	66.7	42.0	80	30	1.43	+0.18	0.0
Kamloops, B. C.	1,262	28.61	29.89	− .08	57.6	+0.2	68.2	47.0	83	38	0.58	−0.27	0.0
Victoria, B. C.	230	29.63	29.88	− .13	55.0	+0.2	60.7	49.2	74	46	3.62	+1.46	0.0
Barkerville, B. C.	4,180	25.53	29.82	− .16	42.7	−4.0	51.3	34.2	65	29	5.39	+2.48	0.0
Triangle Island, B. C.	680												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.92	30.08	+ 0.1	78.9	+1.5	85.0	72.9	88	69	2.23	−4.28	0.0

SEISMOLOGY.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., Nov. 3, 1920.]

TABLE I.—*Noninstrumental earthquake reports, September, 1920.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1919.	*H. m.*		° ′	° ′			*Sec.*			
Sept. 3	4 50	Los Angeles	34 03	118 15	2	3	3	None	Felt by one	P. Hansen.
9	16 44	Palo Alto	37 30	122 06	3	2	2½	....do	Moved desk slightly	W. H. Shockley.
	16 49	San Jose	37 15	121 53	5	1	10	....do	Felt by many	M. Connell.
	16 50	Centerville	37 30	122 00	2	1	10	Rumbling	Felt by several	M. L. Mowry.
	16 57	San Francisco	37 48	122 26	2	1	3	None	Felt by one	M. W. Allen.
15	12 50	Los Angeles	34 03	118 15	2	3	Few.	....do	....do	P. Hansen.
17	6 20	Lakeport	39 03	122 56	3	1	5	....do	Felt by many; window shook	J. Overholser.
18	11 45	Los Angeles	34 03	118 15	3	1	3	....do	Felt by several	P. Hansen.
		UTAH.								
18	21 05	Brigham	41 30	112 00	5	1	.....	Rumbling	5–6 waves; spilled water from bucket.	J. N. Andersen.
18	21 10	Salt Lake City	40 45	111 50	3	1	Few.	None	Felt by many	P. J. O'Gara.
19	13 50	Brigham	41 30	112 00	5	1	.....	Rumble	....do	J. N. Andersen.

TABLE 2.—*Instrumental seismological reports, September, 1920.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see REVIEW for January, 1920, pp. 62–63.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			CALIFORNIA. *Theosophical University, Point Loma.*					
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	.....	.....	.....	100	100	.....	Tremors.
5	.....	.....	.....	.....	150	250	.....	
8	.....	.....	.....	.....	100	200	.....	
11	.....	.....	.....	.....	200	300	.....	
13	.....	.....	.....	.....	100	100	.....	
15	.....	.....	.....	.....	150	300	.....	
17	.....	.....	.....	.....	100	200	.....	
20	.....	.....	.....	.....	100	100	.....	
21	.....	.....	.....	.....	200	300	.....	
			COLORADO. *Sacred Heart College, Denver.*					
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 9–10	.....	.....	.....	.....	.....	.....	.....	Activity on both components during day.
17	.....	.....	.....	.....	.....	.....	.....	Visible activity at intervals during day.
20	.....	P_E	15 02 ..	.....	.....	.....	.....	P not visible on NS.
		S_E	15 12 ..	.....	.....	.....	.....	Numerous sets of waves with intervals of calm between.
		L_E	15 23 ..	18	*1,100	.....	.....	
		L_N	15 24 ..	18	.....	*1,120	.....	
		M_E	15 31 ..	17–18	*1,100	.....	.....	Heavy machinery in motion near by.
		M_N	15 31 ..	17–18	.....	*1,120	.....	
		C_E	17 02 ..	.....	.....	.....	.....	
		C_N	17 02 ..	.....	.....	.....	.....	
		F	17 08 ..	.....	.....	.....	.....	
24	.....	.....	.....	.....	.....	.....	.....	Visible activity at intervals during day.

*Trace amplitude.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*					
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 7	.....	eL_E	6 32 ..	18	.....	.....	.....	
		F	6 37 ..	.....	.....	.....	.....	
8	.....	eP	2 04 ..	.....	.....	.....	.....	
		PR_1	2 07 20	.....	.....	.....	.....	
		S	2 12 56	.....	.....	.....	.....	
		L	2 07 31	.....	.....	.....	.....	
		L	2 07 42	16	.....	.....	.....	
		F	3 15 ..	.....	.....	.....	.....	
9	.....	.....	.....	.....	.....	.....	.....	Slight disturbance (L?) between 19h and 20h, *ca.*
20	.....	P?	14 54 53	.....	.....	.....	8,800	
		S	15 04 50	.....	.....	.....	.....	
		eL	15 23 30	.....	.....	.....	.....	
		L	15 37 ..	24	.....	.....	.....	
		L	15 45 ..	18	.....	.....	.....	
		L	16 06 ..	18	.....	.....	.....	
		L	16 23 ..	18	.....	.....	.....	
		L	16 41 ..	24	.....	.....	.....	
		L	16 46 ..	20	.....	.....	.....	
		F	17 30 *ca*	.....	.....	.....	.....	
21	.....	P	17 54 48	.....	.....	.....	9,400	Very feeble.
		S	18 05 16	.....	.....	.....	.....	
		L	18 44 30	.....	.....	.....	.....	
		F	18 50 *ca*	.....	.....	.....	.....	
24	.....	P	22 01 40	.....	.....	.....	4,200	
		S	22 07 36	.....	.....	.....	.....	
		L	22 13 00	.....	.....	.....	.....	
		F	22 35 ..	.....	.....	.....	.....	
27	.....	e	5 41 20	.....	.....	.....	.....	
		L?	5 42 40	.....	.....	.....	.....	
		F	5 55 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental seismological reports, September, 1920*—Continued.

ILLINOIS. *U. S. Weather Bureau, Chicago.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	P.....	2 54 18	.....	.....	.....	5,700	
		S.....	3 01 40	.....	.....	.....	.....	
		F.....	3 25 *ca*	.....	.....	.....	.....	
3	.....	L_E.....	4 10 *ca*	15	.....	.....	.....	
		L_E.....	4 16 ..	10	.....	.....	.....	
		F.....	4 30 *ca*	.....	.....	.....	.....	
4	.....	P?.....	14 30 04	.....	.....	.....	9,700?	
		S?.....	14 40 50	.....	.....	.....	.....	
		L.....	14 59 45	24	.....	.....	.....	
		L.....	15 17 ..	10	.....	.....	.....	
		F.....	17 10 *ca*	.....	.....	.....	.....	
7	.....	P.....	6 15 30	.....	.....	.....	4,700	
		S.....	6 22 00	.....	.....	.....	.....	
		L.....	6 27 50	14	.....	.....	.....	
		L.....	6 36 ..	12	.....	.....	.....	
		F.....	7 30 *ca*	.....	.....	.....	.....	
	.....	P.....	1 59 47	.....	.....	.....	9,000	
		PR_1...	2 03 31	.....	.....	.....	.....	
		PR_2...	2 05 31	.....	.....	.....	.....	
		S.....	2 10 00	.....	.....	.....	.....	
		SR_1...	2 18 50	.....	.....	.....	.....	
		L?.....	2 26 55	.....	.....	.....	.....	
		L.....	2 41 ..	20	.....	.....	.....	
		L.....	2 48 ..	16	.....	.....	.....	
		F.....	4 50 *ca*	.....	.....	.....	.....	
9	.....	P.....	19 24 54	.....	.....	.....	5,300	
		S.....	19 31 55	.....	.....	.....	.....	
		L.....	19 38 ..	30	.....	.....	.....	
		L.....	19 44 ..	22	.....	.....	.....	
		L.....	20	13	.....	.....	.....	
		F.....	22 10 *ca*	.....	.....	.....	.....	
10	.....	eL.....	22 56 40	20	.....	.....	.....	
		L.....	23 10 ..	16	.....	.....	.....	
		F.....	23 30 *ca*	.....	.....	.....	.....	
17	.....	P.....	23 58 07	.....	.....	.....	3,600	
18	.....	S.....	0 04 00	.....	.....	.....	.....	
		L.....	0 09 03	25	.....	.....	.....	Period decreases rapidly to 15 sec. at 14m.
		F.....	0 40 *ca*	.....	.....	.....	.....	
20	.....	P.....	14 53 48	.....	.....	.....	9,500	P not well recorded on NS component.
		PR_1..	14 58 30	.....	.....	.....	.....	
		S.....	15 04 20	.....	.....	.....	.....	S not well recorded on EW component.
		L?.....	15 22 40	.....	.....	.....	.....	
		M.....	15 41 45	.....	*33,000	.....	.....	L_A again 21h 16m to 21h 30 *m*, small A.
		F.....	20 *ca*. ..	.....	.....	.....	.....	
21	.....	P.....	3 03 30	.....	.....	.....	9,800	Probably same epicenter as preceding quake.
		S.....	3 14 23	.....	.....	.....	.....	
		eL.....	3 33 ..	22	.....	.....	.....	Not well recorded on NS.
		F.....	4 20 *ca*.	.....	.....	.....	.....	
21	.....	eL.....	5 57 15	.....	.....	.....	.....	
		F.....	6 20 *ca*.	.....	.....	.....	.....	
21	.....	P?.....	17 53 23	.....	.....	.....	9,500	Same epicenter as preceding.
		S.....	18 04 00	.....	.....	.....	.....	
		eL.....	18 24 30	.....	.....	.....	.....	
		L.....	18 27 30	18	.....	.....	.....	
		F.....	20 *ca* ..	.....	.....	.....	.....	
23	.....	P.....	5 43 22	.....	.....	.....	9,200	
		S.....	5 53 42	.....	.....	.....	.....	
		L.....	6 11 15	22	.....	.....	.....	
		L.....	6 28 ..	16	.....	.....	.....	
		F.....	6 50 *ca*	.....	.....	.....	.....	
24	.....	P.....	22 01 50	.....	.....	.....	4,300	Waves quite irregular.
		S.....	22 07 55	.....	.....	.....	.....	
		SR1...	22 10 24	.....	.....	.....	.....	
		L_E.....	22 13 00	.....	.....	.....	.....	
		F.....	23 50 *ca*.	.....	.....	.....	.....	
27	.....	P.....	5 31 19	.....	.....	.....	2,700	
		S.....	5 35 40	.....	.....	.....	.....	
		L.....	5 37 40	.....	.....	.....	.....	
		M.....	5 39 45	.....	*6,000	*5,500	.....	
		F.....	6 40 *ca*.	.....	.....	.....	.....	

* Trace amplitude.

NEW YORK. *Cornell University, Ithaca.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 8	.....	e.....	2 12 20	9	.....	.....	.....	
		e.....	2 20 09	12	.....	.....	.....	
		F.....	2 43 ..	.....	.....	.....	.....	
20	.....	eP?...	15 06 24	3	.....	.....	.....	
		eS....	15 18 20	10	.....	.....	.....	
		e.....	15 21 30	16	.....	.....	.....	
		L.....	15 33 20	22	.....	.....	.....	
		F.....	17 01 ..	.....	.....	.....	.....	
24	.....	P_N....	22 02 10	3	.....	.....	.....	
		eS_E...	22 07 54	4	.....	.....	.....	
		L_E....	22 10 47	12	.....	.....	.....	
		L.....	22 12 50	22	.....	.....	.....	
		F.....	22 22 ..	.....	.....	.....	.....	
27	.....	e.....	5 42 12	5	.....	.....	.....	
		L.....	5 43 14	11	.....	.....	.....	
		F.....	5 54 ..	.....	.....	.....	.....	

CANAL ZONE. *Panama Canal, Balboa Heights.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 3	.....	P_E....	16 20 20	.....	.....	.....	257	Direction prob. SW.
		P_N....	16 20 23	.....	.....	.....	.....	
		S_E....	16 20 48	.....	.....	.....	.....	
		S_N....	16 20 51	.....	.....	.....	.....	
		M_E....	16 20 52	.....	*800	.....	.....	
		M_N....	16 21 00	.....	.....	*400	.....	
		F_E....	16 23 35	.....	.....	.....	.....	
		F_N....	16 23 00	.....	.....	.....	.....	
20	.....	.....	.....	.....	.....	.....	.....	Slight tremors from distant quake between 14:30 and 17h; distance and direction unknown.
24	.....	P_E....	21 55 47	.....	.....	.....	579	Direction prob. NW.; distinctly felt at Penonome, R. P.
		P_N....	21 55 44	.....	.....	.....	.....	
		S_E....	21 56 50	.....	.....	.....	.....	
		S_N....	21 56 46	.....	.....	.....	.....	
		L_E....	21 57 20	.....	.....	.....	.....	
		L_N....	21 57 34	.....	.....	.....	.....	
		M_E....	21 57 46	.....	*44,000	.....	.....	
		M_N....	21 58 38	.....	.....	*44,000	.....	
		F_E....	22 19 00	.....	.....	.....	.....	
		F_N....	22 19 40	.....	.....	.....	.....	

VERMONT. *U. S. Weather Bureau, Northfield.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 20	.....	P?.....	15 01 ..	.....	.....	.....	.....	
		eL.....	15 32 ..	40	.....	.....	.....	
		L.....	15 40 ..	24	.....	.....	.....	
		L.....	15 45 ..	18	.....	.....	.....	
		F.....	17 *ca* ..	.....	.....	.....	.....	
27	.....	e.....	5 44 ..	.....	.....	.....	.....	
		F.....	5 50 ..	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental seismological reports, September, 1920*—Continued.

CANADA. *Dominion Observatory, Ottawa.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 4	.....	O.....	(14 17 16)	.....	.....	.....	(8780)	
		$P?_E$...	14 29 17	.....	.....	.....	.....	
		$S?_E$...	14 39 16	.....	.....	.....	.....	
		eL?...	14 57 ..	.....	.....	.....	.....	
		L_E....	15 07 ..	21	.....	.....	.....	
		L_E....	15 20 ..	19	.....	.....	.....	
		L_E....	15 30 ..	17	.....	.....	.....	
		L_E....	15 40 ..	16	.....	.....	.....	
		L_E....	15 45 ..	16	.....	.....	.....	
		$LR1?_E$	16 34 30	.....	.....	.....	.....	
		F.....	16 40 ..	.....	.....	.....	.....	
7	.....	O.....	5 55 44	.....	.....	.....	6450	Italian quake; epicentre in northern Italy.
		P.....	6 05 41	.....	.....	.....	.....	
		S_E.....	6 13 41	.....	.....	.....	.....	
		eL.....	6 23 12	.....	.....	.....	.....	
		L_E....	6 30 ..	17	.....	.....	.....	
		L_E....	6 42 ..	13	.....	.....	.....	
		F.....	7 10 ..	.....	.....	.....	.....	
8	.....	O?.....	1 49 *ca*	.....	.....	.....	10,000	Distance obtained by approx. agreement in $PR1_E$, S_N, eL and $LR1_E$: O obtained by subtracting I_S at 10000 from $S?_N$ at 2–13 *ca*.
		$PR1_N$?	2 05 25	.....	.....	.....	.....	
		e_E.....	2 06 27	.....	.....	.....	.....	
		i_E.....	2 10 51	.....	.....	.....	.....	
		i_E.....	2 12 00	.....	.....	.....	.....	
		S_N?...	2 12 58	.....	.....	.....	.....	
		eL_N...	2 33 ..	40	.....	.....	.....	
		L.....	2 35 ..	40	.....	.....	.....	
		L.....	2 39 ..	22	.....	.....	.....	
		L_E....	2 48 ..	18	.....	.....	.....	
		L_E....	2 53 ..	16	.....	.....	.....	
		L_E....	3 08 ..	16	.....	.....	.....	
		L_E....	3 12 ..	14	.....	.....	.....	
		L_E....	3 20 ..	14	.....	.....	.....	
		L_E....	3 28 ..	13	.....	.....	.....	
		$LR1_E$.	4 00 ..	20	.....	.....	.....	
		F.....	4 20 ..	.....	.....	.....	.....	
9	.....	ePR1?	19 15 31	.....	.....	.....	.....	
		e.....	19 26 23	.....	.....	.....	.....	
		e.....	19 32 47	.....	.....	.....	.....	
		eL?...	19 43 48	.....	.....	.....	.....	
		L_E....	19 46 ..	35	.....	.....	.....	
		L_E....	19 55 ..	28	.....	.....	.....	
		L.....	20 00 ..	23	.....	.....	.....	
		L_E....	20 05 ..	20	.....	.....	.....	
		L_E....	20 16 ..	20	.....	.....	.....	
		L_E....	20 28 ..	17	.....	.....	.....	
		L_E....	20 35 ..	15	.....	.....	.....	
		$LR1_E$.	21 00 ..	23	.....	.....	.....	
		F.....	21 15 ..	.....	.....	.....	.....	
18	.....	e_E.....	0 02 10	.....	.....	.....	.....	NS component masked by micros.
		eL_E...	0 05 38	19	.....	.....	.....	
		F.....	0 22 ..	.....	.....	.....	.....	
20	.....	O.....	14 45 12	.....	.....	.....	9,660	
		P_V....	14 57 57	.....	.....	.....	.....	
		i_E.....	15 04 55	.....	.....	.....	.....	
		i_E.....	15 06 27	.....	.....	.....	.....	
		S_V....	15 08 40	.....	.....	.....	.....	
		eL_N...	15 29 48	50	.....	.....	.....	
		L.....	15 40 ..	27	.....	.....	.....	
		M_E....	15 45 ..	20	1,000	90	.....	A_V, 600 μ.
		L.....	15 55 ..	17	.....	.....	.....	
		L.....	16 06 ..	17	.....	.....	.....	
		L.....	16 21 ..	15	.....	.....	.....	
		L.....	16 45 ..	24?	.....	.....	.....	
		L.....	16 56 ..	17	.....	.....	.....	
		$LR1_V$.	16 56 48	16	.....	.....	.....	
		F.....	18 00 00	.....	.....	.....	.....	
21	.....	eL_E...	3 35 to	24 to	.....	.....	.....	NS component completely obscured by micros.
			3 43	18	.....	.....	.....	
			3 43 ..	18	.....	.....	.....	
		L_E....	3 53 ..	16	.....	.....	.....	
		F.....	4 10 ..	.....	.....	.....	.....	
21	.....	e.....	18 04 24	.....	.....	.....	.....	
		$eL?_E$..	18 19 ..	.....	.....	.....	.....	
		L_E....	18 25 30	.....	.....	.....	.....	
		L_E....	18 30 ..	15	.....	.....	.....	
		L_E....	18 40 ..	15	.....	.....	.....	
		F.....	19 *ca*. ..	.....	.....	.....	.....	
24	.....	O.....	21 54 54	.....	.....	.....	4,340	
		P_N....	22 02 37	.....	.....	.....	.....	
		$PR1_N$.	22 04 07	.....	.....	.....	.....	
		S.....	22 08 43	.....	.....	.....	.....	
		eL_E...	22 11 16	.....	.....	.....	.....	
		L_E....	22 15 30	22	.....	.....	.....	
		L_E....	22 28 ..	10	.....	.....	.....	
		F.....	23 15 ..	.....	.....	.....	.....	
27	.....	O?.....	5 24 34	.....	.....	.....	4,220	
		$P_E?$...	5 32 08	.....	.....	.....	.....	
		$S_E?$...	5 38 08	.....	.....	.....	.....	
		eL.....	5 43 38	20	.....	.....	.....	
		L.....	5 54 ..	8	.....	.....	.....	
		L.....	6 03 ..	9	.....	.....	.....	
		F.....	6 30 ..	.....	.....	.....	.....	
28	.....	e.....	0 31 54	.....	.....	.....	.....	
		F.....	0 56 00	.....	.....	.....	.....	

CANADA. *Dominion Meteorological Service, Toronto.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1	.....	L.....	3? 04 00	.....	*100	.....	.....	Doubtful as to being seismic.
4	.....	P.....	15 12 54	.....	.....	.....	.....	
		i.....	15 16 30	.....	.....	.....	.....	
		S?.....	15 19 42	.....	.....	.....	.....	
		L.....	15 27 30	.....	.....	.....	.....	
		M.....	15 29 30	.....	*300	.....	.....	
		F.....	16 00 42	.....	.....	.....	.....	
7	.....	eL.....	6 31 18	.....	.....	.....	.....	
		M.....	6 33 24	.....	*200	.....	.....	
		F.....	6 41 06	.....	.....	.....	.....	
8	.....	S.....	2 12 06	.....	.....	.....	.....	Faint trace. Italian quake.
		L.....	2 14 54	.....	.....	.....	.....	
		M.....	2? 15 54	.....	*500?	.....	.....	
		L?.....	2 52 00	.....	.....	.....	.....	
		eL.....	2 53 06	.....	.....	.....	.....	
		M.....	2 57 48	.....	*800	.....	.....	
		F.....	4? 09 48	.....	.....	.....	.....	
9	.....	i.....	19 07 12	.....	*300	.....	.....	P preceded by small micros.
		P?.....	19 15 12	.....	.....	.....	.....	
		S.....	19 25 06	.....	.....	.....	.....	Difficult seismogram to read.
		e?.....	19 27 54	.....	.....	.....	.....	
		L.....	19 54 54	.....	.....	.....	.....	
		iL.....	19 58 48	.....	.....	.....	.....	
		L.....	20 08 12	.....	.....	.....	.....	
		eL.....	20 16 12	.....	.....	.....	.....	
		M.....	20 16 36	.....	*500	.....	.....	
		L.....	21 05 30	.....	.....	.....	.....	
		L.....	21 24 30	.....	.....	.....	.....	
		F.....	21 32 36	.....	.....	.....	.....	
18	.....	i.....	0 01 36	.....	.....	.....	.....	
		eL.....	0 07 42	.....	.....	.....	.....	
		M.....	0 11 48	.....	*800	.....	.....	
		F.....	0 18 00	.....	.....	.....	.....	
20	.....	P?.....	14 57 42	.....	.....	.....	.....	
		i?.....	14 59 18	.....	.....	.....	.....	
		i.....	15 06 54	.....	.....	.....	.....	
		iS.....	15 08 30	.....	.....	.....	.....	
		L.....	15 15 18	.....	.....	.....	.....	
		L.....	15 40 18	.....	.....	.....	.....	
		L.....	15 40 54	.....	.....	.....	.....	Trace rather faint.
		M?.....	15 49 48	.....	*23000?	.....	.....	
		eL.....	16 55 54	.....	.....	.....	.....	
		F.....	18 32 36	.....	.....	.....	.....	
21	.....	eL.....	3 38 54	.....	.....	.....	.....	Micros 3:23:18 to 3:25:06.
		M.....	3 46 24	.....	*300	.....	.....	
		F.....	3 51 12	.....	.....	.....	.....	
24	.....	S.....	22 08 42	.....	.....	.....	.....	P not recorded.
		eL.....	22 12 24	.....	.....	.....	.....	
		eL.....	22 15 36	.....	.....	.....	.....	
		M.....	22 17 24	.....	*2000	.....	.....	
		F.....	23 06 24	.....	.....	.....	.....	
24	.....	L.....	23 46 36	.....	*200	.....	.....	
		F.....	23 49 54	.....	.....	.....	.....	
27	.....	i.....	5 30 54	.....	.....	.....	.....	
		eL.....	5 42 06	.....	.....	.....	.....	
		M.....	5 45 30	.....	*900	.....	.....	
		F.....	6 30 54	.....	.....	.....	.....	

*Trace amplitude.

TABLE 2.—*Instrumental seismological reports, September, 1920*—Contd.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_H	Amplitude. A_N	Distance.	Remarks.
			CANADA. *Dominion Meterological Service, Victoria.*					
1920.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 1	.....	P.....	3 03 13	.....	.....	.....	.....	
		M.....	3 08 37	.....	*200	.....	.....	
		F.....	3 17 28	.....	.....	.....	.....	
4	.....	P.....	14 58 02	.....	.....	.....	.....	
		M.....	15 32 58	.....	*200	.....	.....	
		F.....	16 22 38	.....	.....	.....	.....	
7	.....	P?.....	6 28 14	.....	.....	.....	.....	
		L.....	6 35 07	.....	.....	.....	.....	
		M.....	6 39 48	.....	*300	.....	.....	
		F.....	6 49 22	.....	.....	.....	.....	
8	.....	S.....	1? 58 47	.....	.....	.....	.....	
		L.....	2 08 38	.....	.....	.....	.....	
		eL.....	2 15 09	.....	.....	.....	.....	
		M.....	2 17 58	.....	*500	.....	.....	
		F.....	3 16 00	.....	.....	.....	.....	
9	.....	P.....	19 09 11	.....	.....	.....	8570	
		S.....	19 19 01	.....	.....	.....	.....	
		L.....	19 31 48	.....	.....	.....	.....	
		M.....	19 37 13	.....	*500	.....	.....	
		F.....	21 42 08	.....	.....	.....	.....	
18	.....	M.....	0 27 09	.....	*200	.....	.....	
20	.....	P.....	14 51 26	.....	.....	.....	2390	Alaska.
		S.....	14 55 22	.....	.....	.....	.....	
		L.....	15 02 16	.....	.....	.....	.....	
		M_1.....	15 23 54	.....	*5500	.....	.....	
		M_2.....	15 31 07	.....	*3500	.....	.....	
		eL.....	16 54 30	.....	.....	.....	.....	
		eL.....	17 06 24	.....	.....	.....	.....	
		M.....	17 13 12	.....	*2000	.....	.....	
		F.....	18 44 33	.....	.....	.....	.....	
				VERTICAL.				
		P.....	*14 51 30*	*2*	.....	.....	*2620*	
		S.....	*14 55 45*	*7*	.....	.....	.....	
		L.....	*15 02 30*	.....	.....	.....	.....	
		M.....	*15 19 31*	*30*	.....	*10*	.....	
24	.....	L.....	5 49 46	.....	.....	.....	.....	
		M.....	5 53 42	.....	*100	.....	.....	
24	.....	P.....	22 12 29	.....	.....	.....	.....	
		L.....	22 22 19	.....	.....	.....	.....	
		M.....	22 29 32	.....	*500	.....	.....	
		F.....	22 46 24	.....	.....	.....	.....	
27	.....	P?.....	5 35 16	.....	.....	.....	1400	Real P may not be recorded. Alaska.
		L.....	5 37 43	.....	.....	.....	.....	
		M.....	5 41 10	.....	*500	.....	.....	
		F.....	5 50 30	.....	.....	.....	.....	

*Trace amplitude.

Reports for September, 1920, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.
ALASKA. *U. S. C. & G. S. Magnetic Observatory*, Sitka.
ARIZONA. *U. S. C. & G. S. Magnetic Observatory*, Tucson.
DISTRICT OF COLUMBIA. *Georgetown University*, Washington.
HAWAII. *U. S. C. & G. S. Magnetic Observatory*, Honolulu.
KANSAS. *University of Kansas*, Lawrence.
MARYLAND. *U. S. C. & G. S. Magnetic Observatory*, Cheltenham.
MASSACHUSETTS. *Harvard University*, Cambridge.
MISSOURI. *St. Louis University*, St. Louis.
NEW YORK. *Canisius College*, Buffalo; *Fordham University*, New York.
PORTO RICO. *U. S. C. & G. S. Magnetic Observatory*, Vieques.

SEISMOLOGICAL DISPATCHES.[1]

Los Angeles, September 3.

A light earthquake shock was felt in outlying parts of the city early to-day. No damage was reported.—*Associated Press.*

[1] Collected by seismological station, Georgetown University, Washington, D. C.

London, September 7.

The town of Fivizzano, 34 miles northwest of Lucca, has been completely demolished by an earthquake, according to a Spezia dispatch to the Exchange Telegraph. The dispatch adds that Solero and Monte were badly wrecked.—*Associated Press.*

Rome, September 7.

The earthquake in northern Italy was of a violent nature. Villa Collemandina is reported to have been destroyed. Castiglione, Pieve Fosciano, Vaglia, Camporgiano, San Donnino, Piasza Alserchio, Poggio, Castegnola, Fosciendora, and Canigiano have been badly damaged.—*Associated Press.*

Pisa, Italy, September 7.

The earthquake shock here was preceded by deep rumblings and followed by vertical and horizontal earth tremors which lasted for 13 seconds. The hands of the clock in the tower stopped at 7.55 o'clock this morning.—*Associated Press.*

Rome, September 9.

Another violent earthquake occurred in the Emilia district at 2.35 o'clock this morning, causing loss of lives and important damage. The communities suffering the most were Reggio, Ospedaletti, Bussana, Toano, and Cavola. This morning's shock was more violent than that of Tuesday. The Epoca estimates that the dead in the earthquake of Tuesday exceed 500 and the homeless more than 20,000.—*Associated Press.*

Riverside, Calif., September 10.

An earthquake shock was felt here this morning about 5.16. It was of sufficient violence to awaken sleepers and many persons fled into the open until the tremors subsided. No damage was reported.—*Associated Press.*

Rome, September 10.

Earthquake shocks continue, causing more victims among the rescuers owing to falling masonry. To-day there were shocks as far south as Cassino, near Naples. Apparently there was no serious damage nor victims, but the shocks produced great panic among the population, which recalled its experiences in the earthquake of 1915. A volcanic crater has suddenly opened at the top of Pizzo d'Ucello, a mountain 5,845 feet high about 9 miles northeast of Spezia. It is located on what appears to be the northeast corner of the district shaken by Tuesday morning's earthquake, which resulted in the loss of hundreds of lives in the region just north of Florence. A telegram from Spezia states the crater is emitting smoke and sulphuric fumes and that scientists there attribute the volcanic outbreak to the earthquake.—*Associated Press.*

Geneva, Switzerland, September 10.

A severe earthquake shook the southern slopes of the Swiss and Italian Alps yesterday from Monterosa to Bernina Pass, causing avalanches. The shock was accompanied by heavy snowfalls, and several Alpine villages are isolated. Four persons are reported to have been killed and many injured. Slighter shocks also were reported in the Swiss Alps around Zermatt and Ponterosina, but there were no casualties.—*Associated Press.*

Rome, September 10.

Minor earthquake shocks which have been felt since Tuesday morning in the devastated zone north of Florence indicate the disturbance is subsiding, according to Father Alfani, director of the observatory here. He

said that small shocks succeeding each other rather frequently show the seismic phenomena are wearing out. "The shocks in the present case," he declared, "are to be considered as good omens as indicating that no serious recurrence of the earthquake may be expected."—*Associated Press.*

Berlin, September 10.

The seismographic station at Jeno suggests as the possible cause of the Italian earthquake a sinking of the earth along the mountains bordering the Gulf of Genoa. Experts there say it indicates a massive caving zone in the earth's crust.—*Associated Press.*

Comrie, County of Perth, Scotland, September 13.

An earthquake shock was experienced here this morning. The inhabitants were awakened when their beds and furniture were shaken by the shock. A dull rumbling sound accompanied the shock.—*Associated Press.*

Rome, September 15.

Scientists say they do not believe that a new volcano was created on Mount Pisanino, near Spezia, during the earthquakes which began September 7 and continued until September 9 causing the loss of 500 lives. Tongues of flame and smoke or dust were seen to be emitted from what is popularly supposed to have been a new crater opened near the mountain top. Frank A. Perrett, the American volcanologist for the Carnegie Institution who occupies a station at Mount Vesuvius to observe its operations, has expressed to the Associated Press the opinion that no new volcano has been formed but that the earthquakes caused displacements of subterranean strata causing a fissure in the earth's crust and that gas escaping therefrom was mistaken by onlookers as the opening of a new crater.—*Associated Press.*

Vienna, September 23.

Slow moving landslides covering considerable territory are doing considerable damage in the Sandling Alps of upper Austria. The entire mountain surface apparently is settling into the Leisling Valley. Many huts have been destroyed, and hamlets, forests and fields are moving bodily, accompanied by tremendous noises.—*Associated Press.*

London, September 27.

A violent earthquake is reported to have occurred at Giarre, Sicily, according to a Rome dispatch to the Exchange Telegraph Co. Giarre lies at the base of Mount Etna. The quake lasted 10 seconds. One village was destroyed and many persons were injured.—*Associated Press.*

Madrid, September 28.

Widespread alarm was caused in the vicinity of Crihuela, about 35 miles north of Cartagena, when a sharp earth shock occurred at 10.45 o'clock Sunday night, according to advices received here. Many families passed the night in the fields, fearing a repetition.—*Associated Press.*

Catania, Sicily, September 29.

Relief measures for the victims of the earthquake near here on Sunday are being expedited, and many persons injured during the disaster have been rescued from the ruins. The shock was most violent at Giarre, and the village of Codadivolpe, nearby, was demolished. The damage throughout the district was enormous.—*Associated Press.*

LATE REPORTS.

TABLE 2—*Instrumental reports.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
DISTRICT OF COLUMBIA. *Georgetown University, Washington.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3	.....	e_E	3 24 —	.....	.....	.....	.....	
		e_N	3 24 —	.....	.....	.....	.....	
		F	3 35 —	.....	.....	.....	.....	
3	.....	eP_E	20 08 11	.....	.....	.....	.....	
		eP_N	20 08 11	.....	.....	.....	.....	
		S_E	20 17 11	.....	.....	.....	.....	
		S_N	20 17 11	.....	.....	.....	.....	
		eL	20 28 12	.....	.....	.....	.....	
		L	20 31 37	26	.....	.....	.....	
		F	21 20 —	.....	.....	.....	.....	
13	.....	e_E	8 37 10	.....	.....	.....	.....	Heavy micros.
		L_E	9 25 11	18	.....	.....	.....	
		L_N	9 25 10	17	.....	.....	.....	
		F	10 30 —	.....	.....	.....	.....	
20	.....	eL_E	16 56 12	24	.....	.....	.....	Sheets taken off at 16h 21m, put on at 16h 29m, quake then in progress.
		eL_N?	16 56 00	24	.....	.....	.....	
		L_E	17 03 —	11	.....	.....	.....	
		L_N	17 01 16	16	.....	.....	.....	
		F	18 — —	.....	.....	.....	.....	
26	.....	iP_E	23 10 13	.....	.....	.....	.....	
		iP_N	23 10 14	.....	.....	.....	.....	
		S_E	23 18 31	.....	.....	.....	.....	
		eL	23 30 —	.....	.....	.....	.....	
		L_E	23 33 —	9	.....	.....	.....	
		L_N	23 34 11	20	.....	.....	.....	
27	.....	F	0 30 —	.....	.....	.....	.....	
NEW YORK. *Cornell University, Ithaca.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	.....	e_E	22 13 30	4	.....	.....	.....	Irregular, short period waves.
		L	22 18 14	21	.....	.....	.....	
		F	22 36 —	.....	.....	.....	.....	
4	.....	e	15 41 —	.....	.....	.....	.....	
		F	16 02 —	.....	.....	.....	.....	
5	.....	P	4 39 25	4	.....	.....	.....	
		L	5 12 20	35	.....	.....	.....	
		F	6 20 —	.....	.....	.....	.....	
18	.....	e	10 25 30	4	.....	.....	.....	
		F	10 34 30	.....	.....	.....	.....	
22	.....	e	3 05 30	10	.....	.....	.....	
		F	3 13 —	.....	.....	.....	.....	
July 2	.....	L	19 40 —	24	.....	.....	.....	
		F	19 58 —	.....	.....	.....	.....	
7	.....				.....	.....	.....	Quake after 18 hr.; seismograph out of order.
8	.....	e	1 00 09	3	.....	.....	.....	
		L	1 03 02	7	.....	.....	.....	
		F	1 07 —	.....	.....	.....	.....	
Aug. 3	.....				.....	.....	.....	Time marker not recording; beginning 20 hr. ca., L–S 12 min, ca.
13	.....	e	2 13 —	4	.....	.....	.....	
		F	2 24 —	.....	.....	.....	.....	
15	.....	eL	9 09 —	28	.....	.....	.....	
		F	9 16 —	.....	.....	.....	.....	
20	.....	eP	16 27 10	4	.....	.....	.....	
		S	16 37 12	6	.....	.....	.....	
		L	16 51 38	38	.....	.....	.....	
		F	18 08 —	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports*—Continued.

CANADA. *Dominion Meteorological Service, Toronto.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3	.....	L?	3 20 48	.....	*200	.....	.....	Micros going on.
3	.....	P?	20 06 36	.....	.....	.....	.....	P preceded by minute micros.
		iP?	20 11 24	.....	.....	.....	.....	
		iS	20 19 12	.....	.....	.....	.....	
		eL	20 33 18	.....	.....	.....	.....	
		eL	20 42 30	.....	.....	.....	.....	
		M	20 47 30	.....	*1400	.....	.....	
		eL	20 55 36	.....	.....	.....	.....	
		eL	21 11 12	.....	.....	.....	.....	
		F	.....	.....	.....	.....	.....	Micros.
11	.....	eL	20 13 24	.....	.....	.....	.....	Micros going on.
		eL	20 14 24	.....	.....	.....	.....	
		M	20 15 36	.....	*800	.....	.....	
		F	.....	.....	.....	.....	.....	Micros.
12	.....	eL	6 39 30	.....	.....	.....	.....	
		M	6 42 06	.....	*200	.....	.....	
		F	6 45 54	.....	.....	.....	.....	Gradual thickening.
13	.....	i?	2 12 18	.....	.....	.....	.....	
		L	2 22 00	.....	.....	.....	.....	
		M	2 23 18	.....	*200	.....	.....	
		F	2 32 30	.....	.....	.....	.....	
15	.....	S	8 46 54	.....	.....	.....	.....	
		M	8 49 42	.....	*700	.....	.....	
		L	9 02 42	.....	.....	.....	.....	
		eL	9 21 12	.....	.....	.....	.....	
		eL	9 28 48	.....	.....	.....	.....	
		F	10 45 30	.....	.....	.....	.....	
20	.....	L	17 02 24	.....	.....	.....	.....	Light turned down 16:38 to change paper.
		eL	17 08 36	.....	.....	.....	.....	
		M	17 10 18	.....	*700	.....	.....	
		eL	17 21 24	.....	.....	.....	.....	
		F	17 38 48	.....	.....	.....	.....	
26	.....	L	22 53 48	.....	*200	.....	.....	May not be seismic.
		F	22 56 48	.....	.....	.....	.....	
26	.....	P	23?09 06	.....	.....	.....	.....	
		i	23 12 42	.....	.....	.....	.....	
		S	23 17 24	.....	.....	.....	.....	
		eL	23 32 48	.....	.....	.....	.....	
		M	23 39 48	.....	*800	.....	.....	
		F	1?21 12	.....	.....	.....	.....	
29	.....	eL	11 53 48	.....	.....	.....	.....	
		M	11 57 18	.....	*200	.....	.....	
		F	12 01 12	.....	.....	.....	.....	

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3	.....	P	3?18 42	.....	.....	.....	.....	
		S	3?26 34	.....	.....	.....	.....	
		L	3?41 19	.....	.....	.....	.....	
		M	3 53 05	.....	*100	.....	6300?	
		F	4 30 30	.....	.....	.....	.....	
3	.....	P?	20 20 42	.....	.....	.....	3620?	Probably from Aleutian Islands. Fine marks indistinct.
		S?	20 26 07	.....	.....	.....	.....	
		L	20 34 28	.....	.....	.....	.....	
		M	20 41 21	.....	*1500	.....	.....	
		F	22 44 18	.....	.....	.....	.....	
11	.....	P	20 38 51	.....	.....	.....	.....	
		L	20 41 45	.....	.....	.....	.....	
		M	20 44 42	.....	*200	.....	.....	
		F	20 51 35	.....	.....	.....	.....	
12	.....	P	6?51 35	.....	.....	.....	.....	
		M	6 58 28	.....	*200	.....	.....	
		F	7 09 48	.....	.....	.....	.....	
15	.....	P	8 28 05	.....	.....	.....	.....	
		L	8 38 54	.....	.....	.....	.....	
		M	8 45 47	.....	*600	.....	.....	
		F	10 57 36	.....	.....	.....	.....	
17	.....	M	3 17 14	.....	*50	.....	.....	
20	.....	P	16 39 08	.....	.....	.....	.....	
		S	16 47 30	.....	.....	.....	.....	
		L	16 58 19	.....	.....	.....	.....	
		M	17 06 41	.....	*600	.....	6860	
		F	18 58 48	.....	.....	.....	.....	
25	.....	M	22 44 39	.....	*200	.....	.....	
26	.....	P	23 01 09	.....	.....	.....	3170	
		S	23 06 04	.....	.....	.....	.....	
		L	23 10 30	.....	.....	.....	.....	
		M	23 15 25	.....	*1000	.....	.....	
27	.....	F	0 08 32	.....	.....	.....	.....	

* Trace amplitude.

Chart I. Hydrographs of Several Principal Rivers, September, 1920.

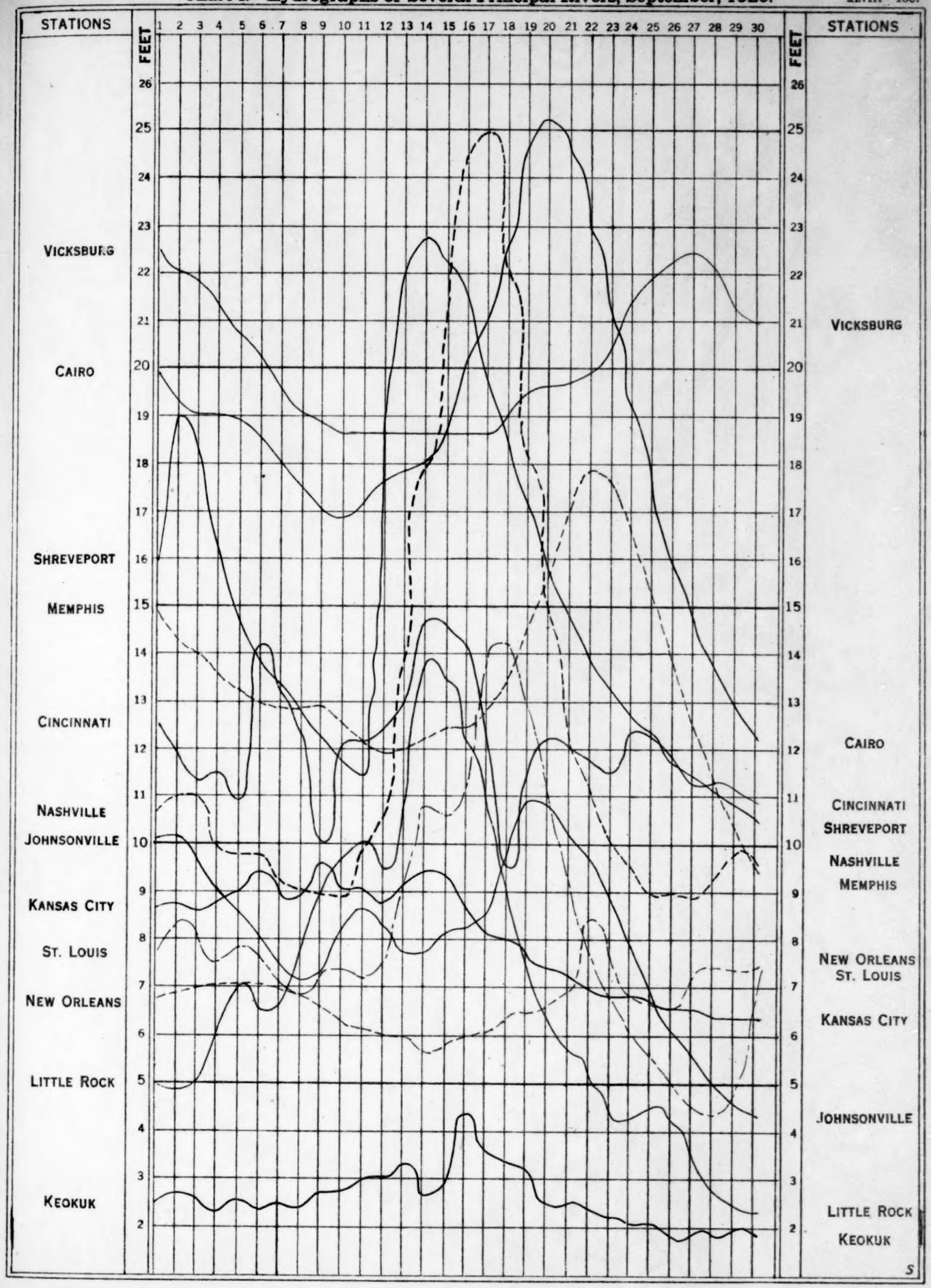


Chart II. Tracks of Centers of High Areas, September, 1920.

(Plotted by Herbert Lyman.)

Chart III. Tracks of Centers of Low Areas, September, 1920.

(Plotted by Herbert Lyman.)

Chart III. Tracks of Centers of Low Areas, September, 1920.

(Plotted by Herbert Lyman.)

September, 1920. M. W. R.

21571°—132.

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, September, 1920.

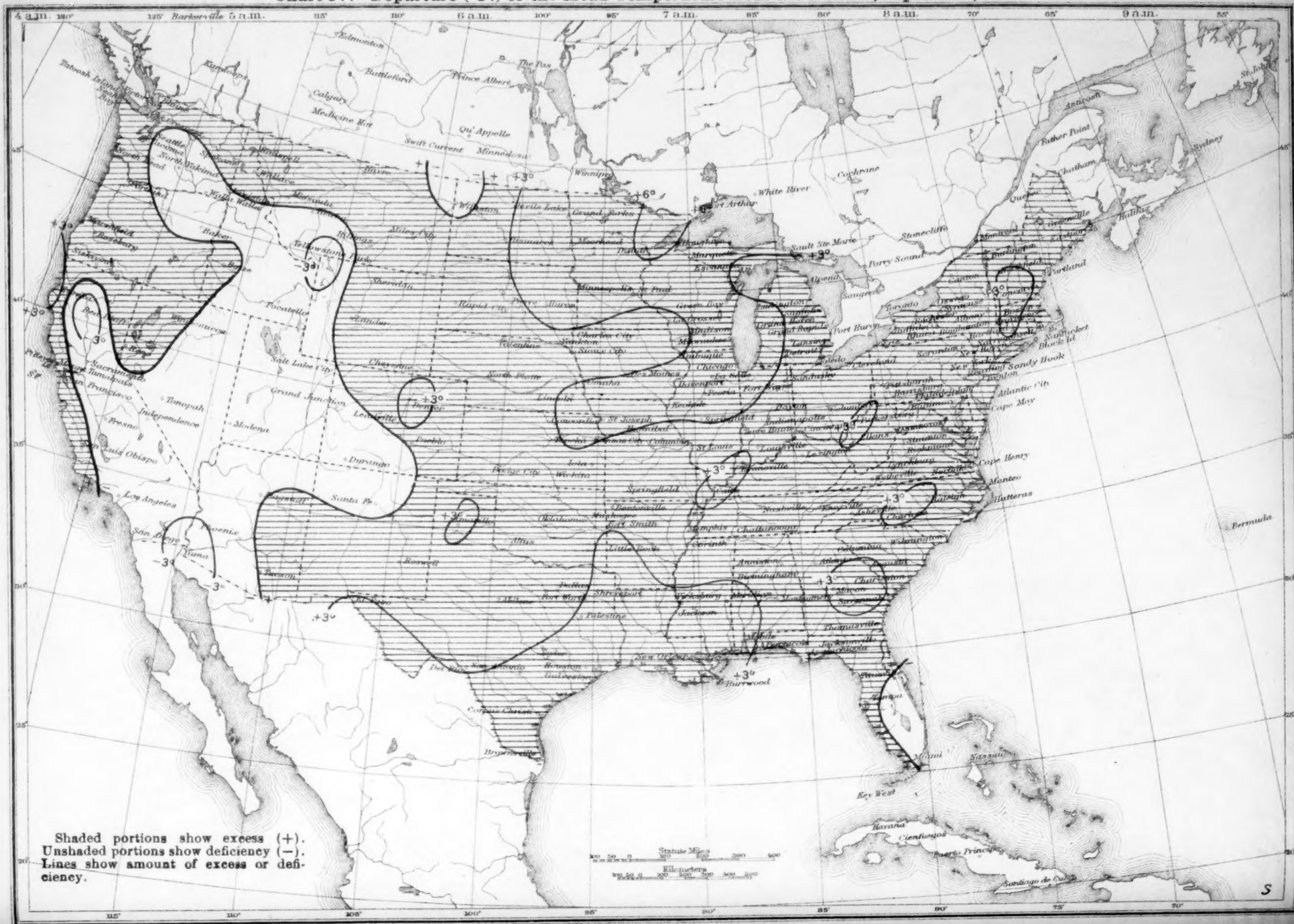

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart V. Total Precipitation, Inches, September, 1920.

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, September, 1920.

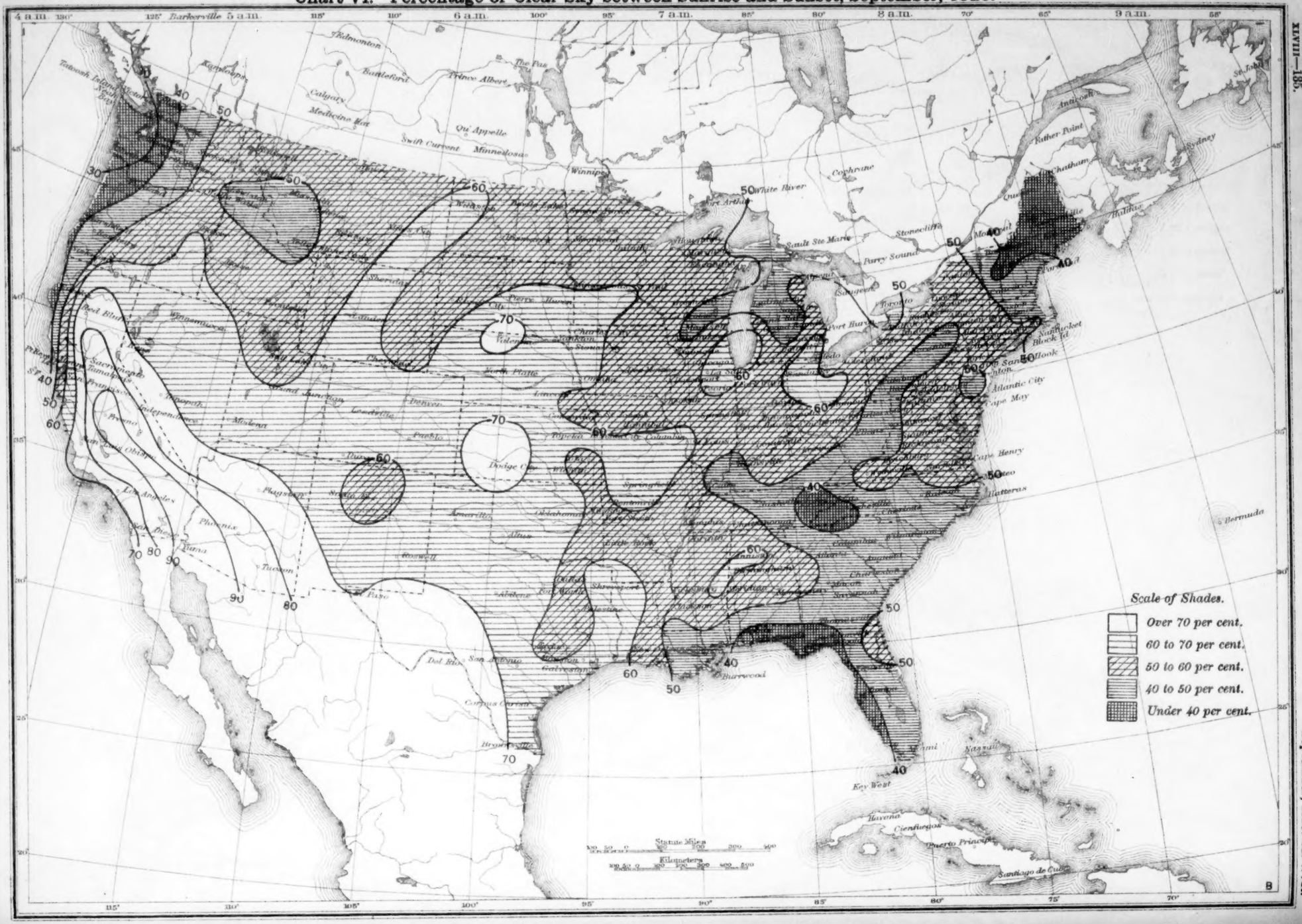


Chart VII. Isobars and Isotherms at Sea-level; Prevailing Winds, September, 1920.

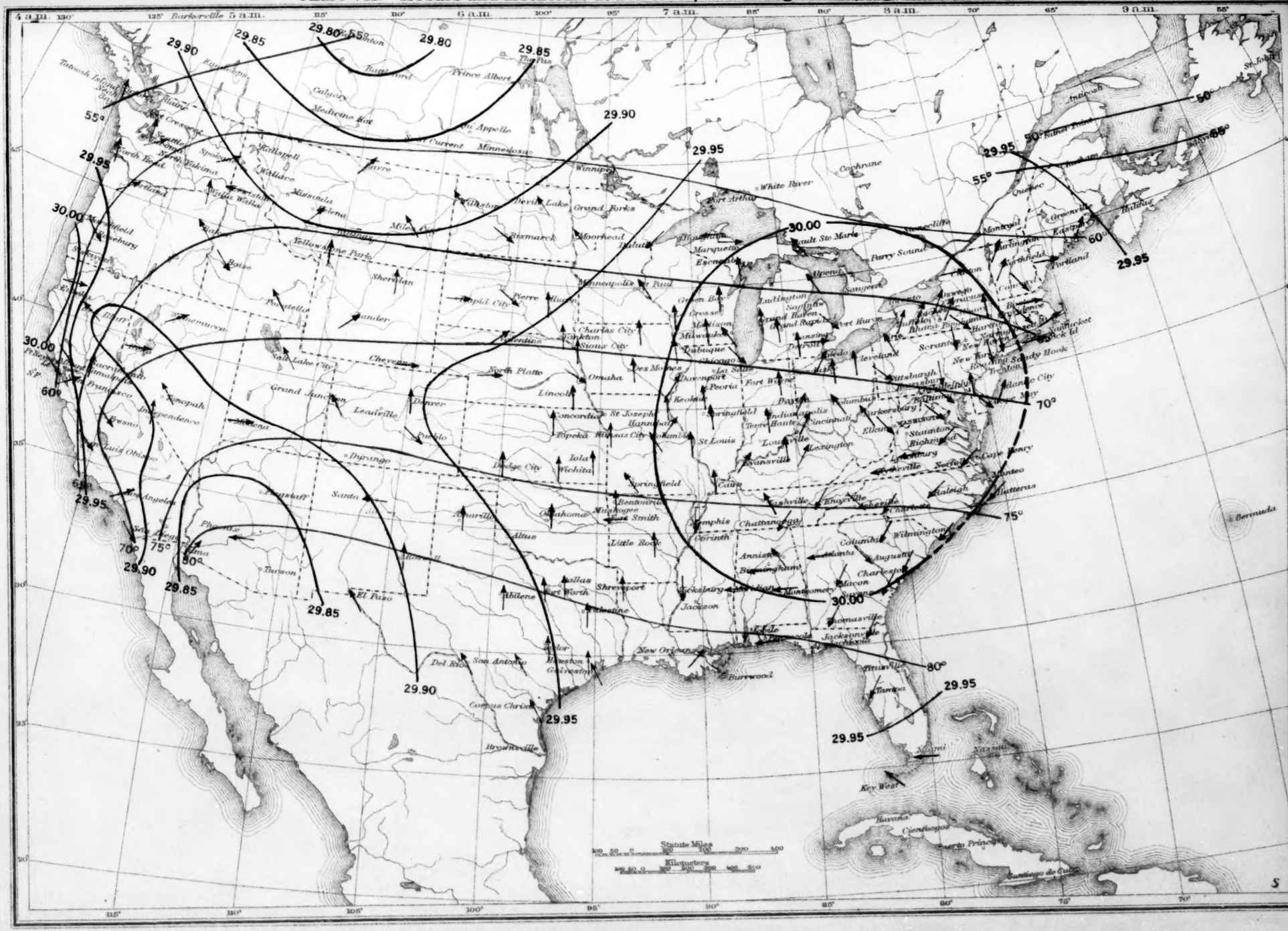


Chart IX. Weather Map of North Atlantic Ocean, September 9, 1920.
(Plotted by E. A. Kerns.)

Chart IX. Weather Map of North Atlantic Ocean, September 9, 1920.

(Plotted by F. A. Young.)

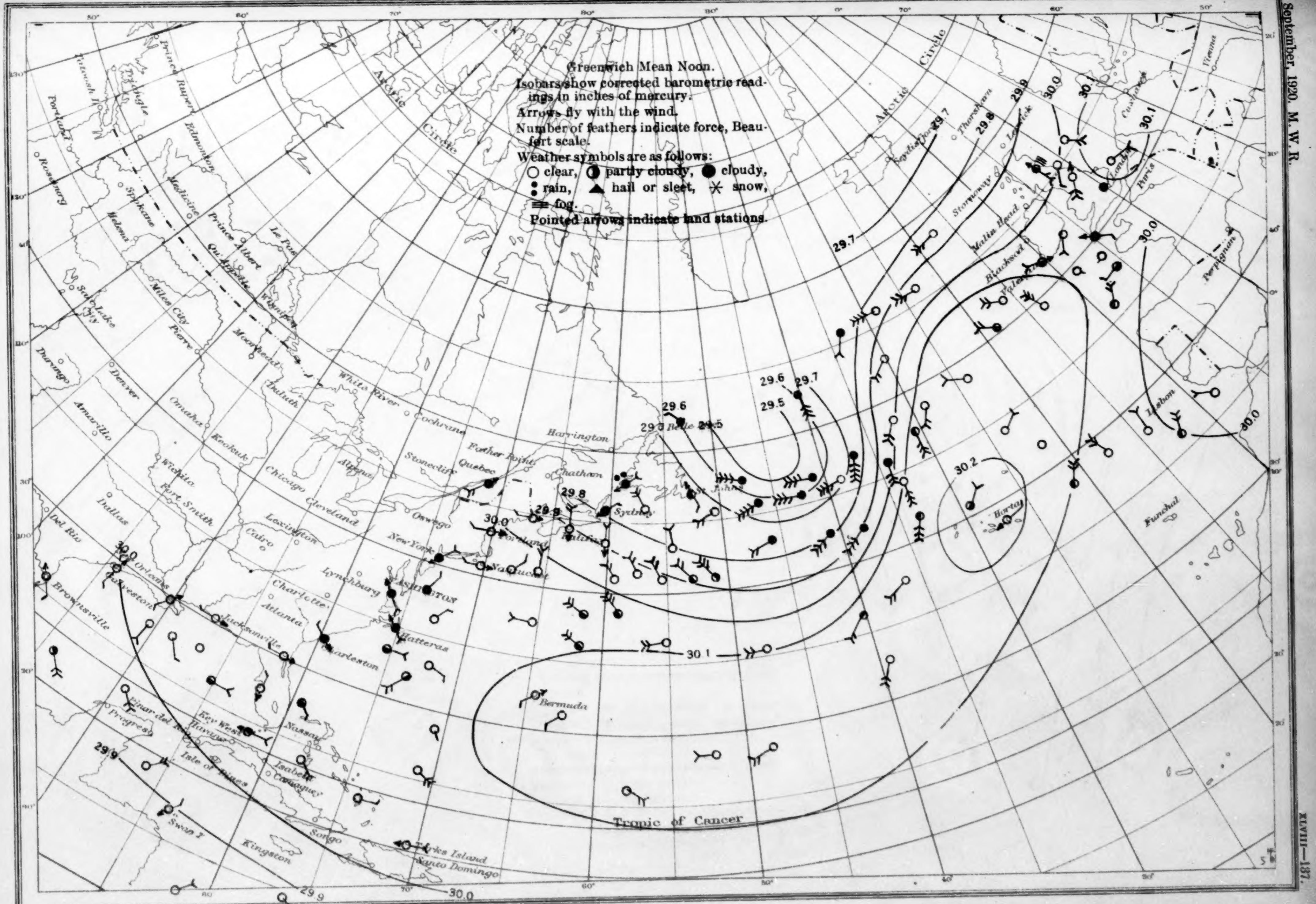


Chart X. Weather Map of North Atlantic Ocean, September 21, 1920.

(Plotted by F. A. Young.)

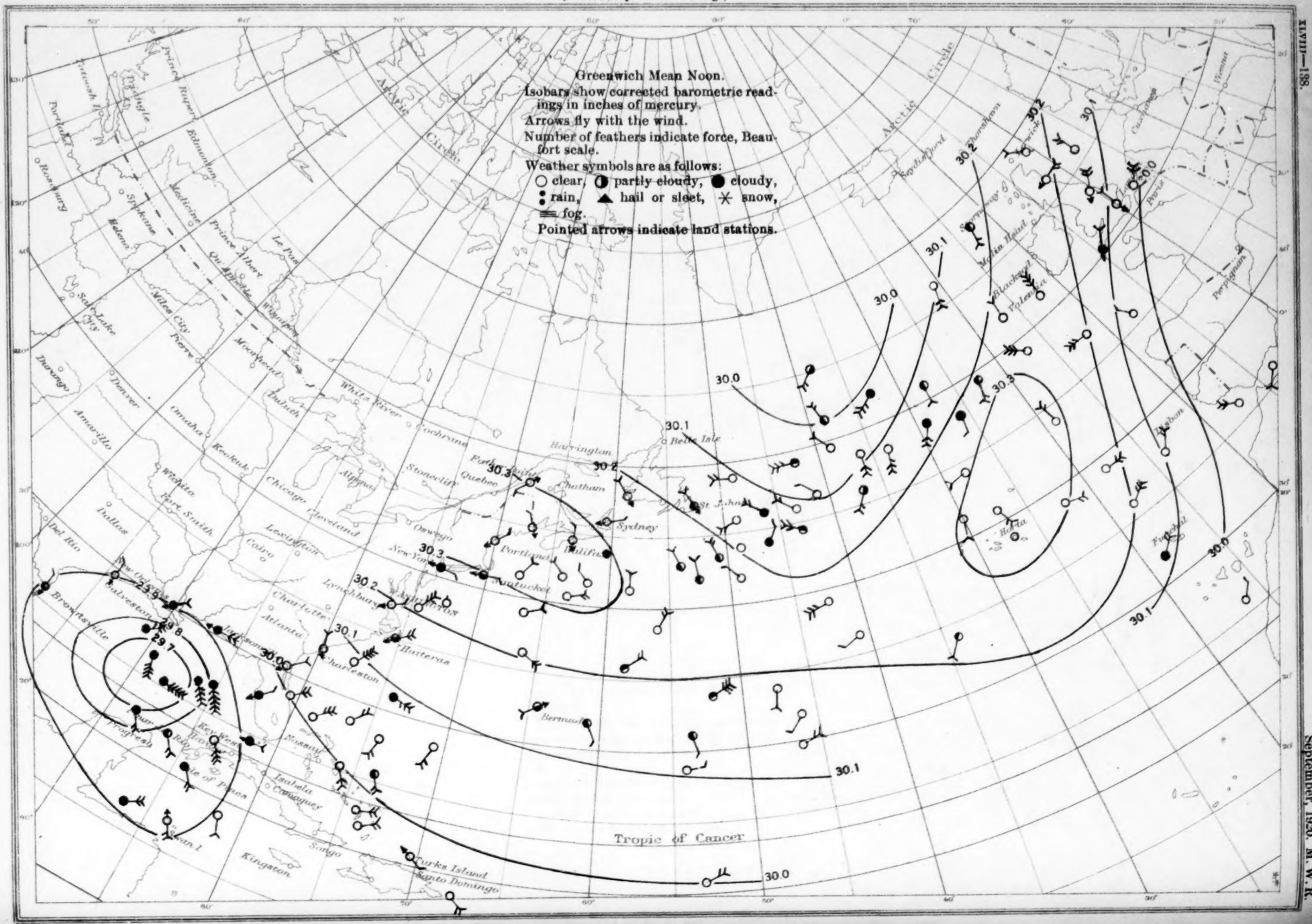
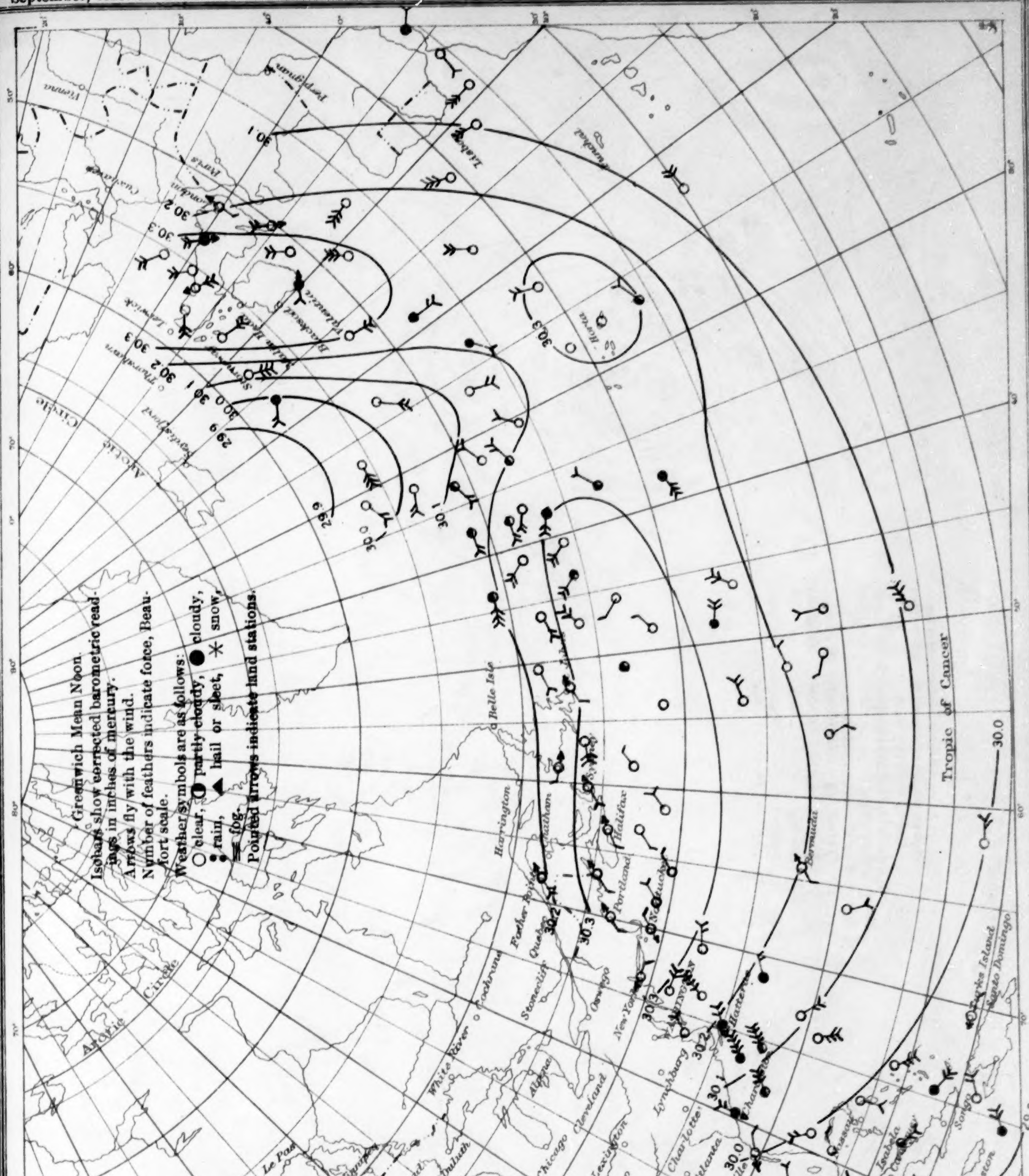


Chart XI. Weather Map of North Atlantic Ocean, September 22, 1920.

Chart XI. Weather Map of North Atlantic Ocean, September 22, 1920.
(Plotted by F. A. Young.)



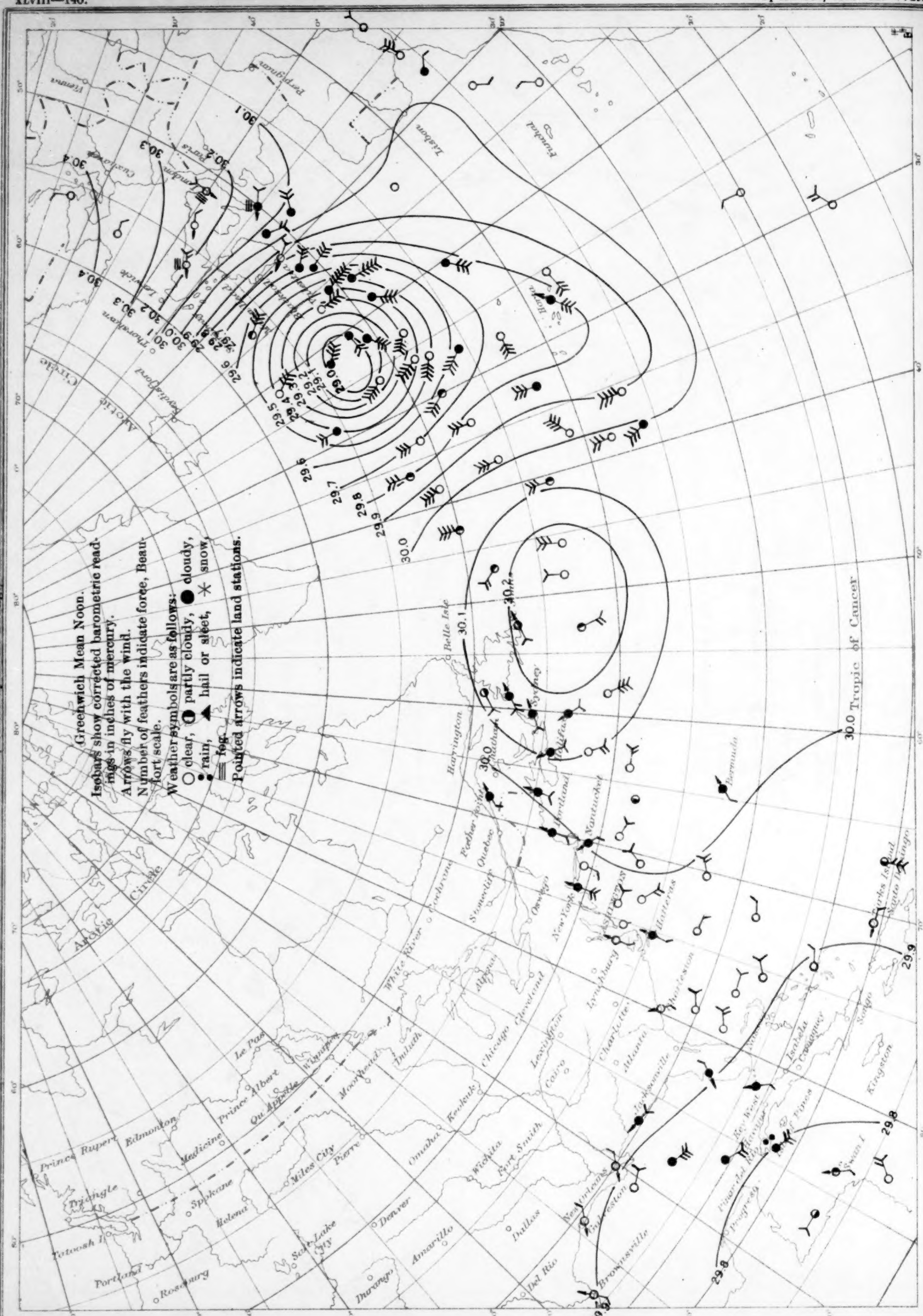


Chart XII. Weather Map of North Atlantic Ocean, September 28, 1920.
(Plotted by F. A. Young.)

Chart XIII. Weather Map of North Atlantic Ocean, September 29, 1920.

(Plotted by F. A. Young.)

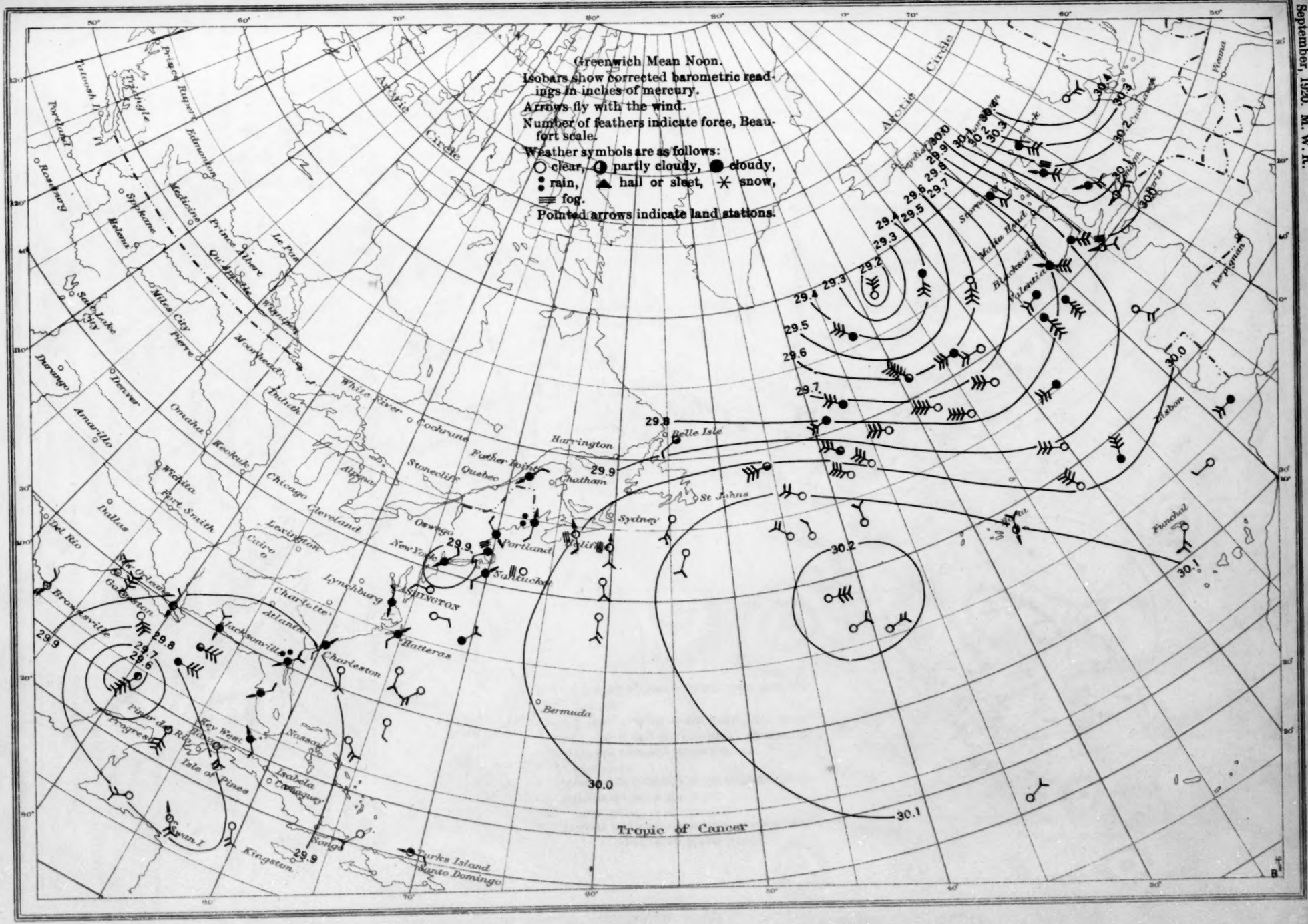
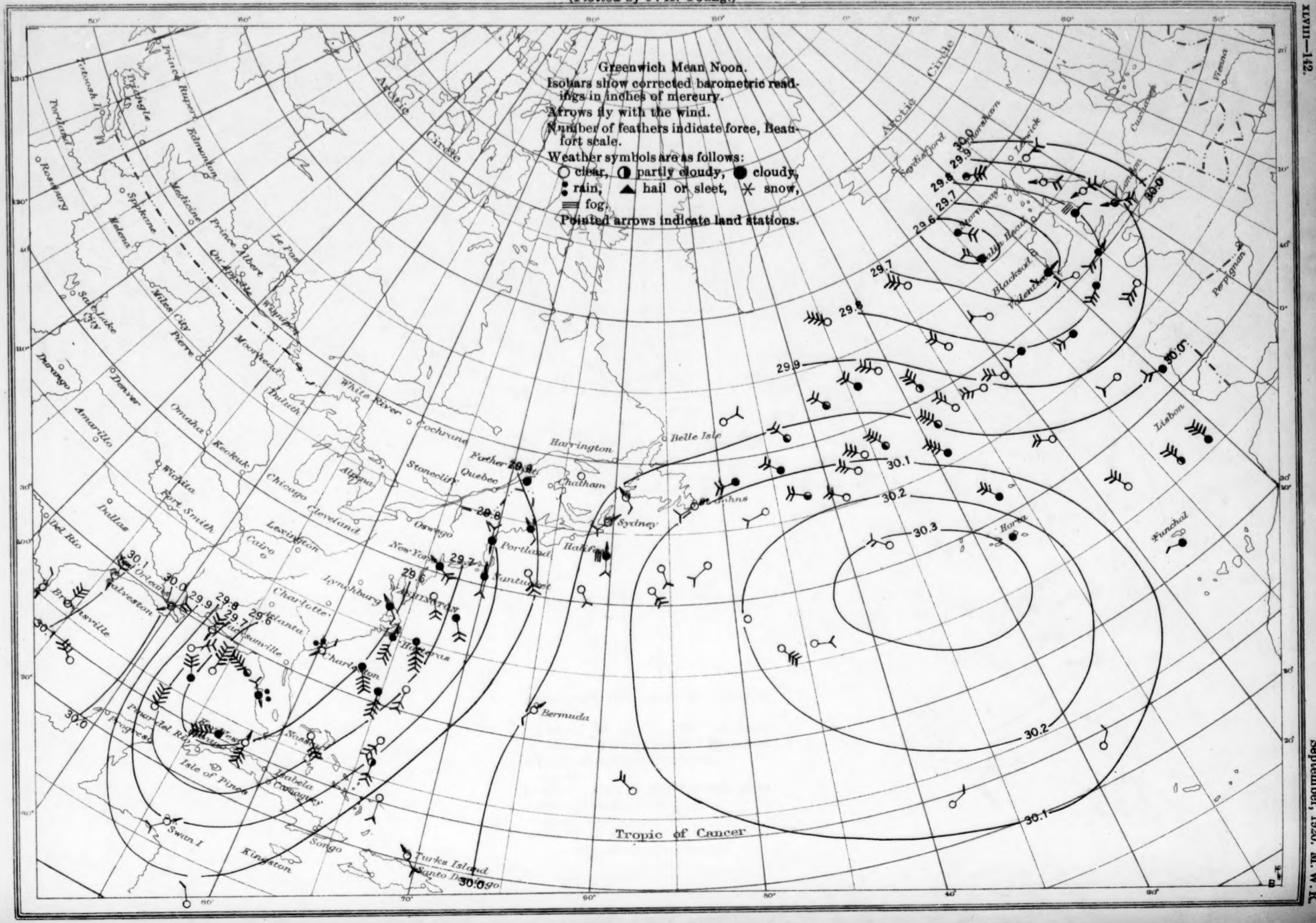
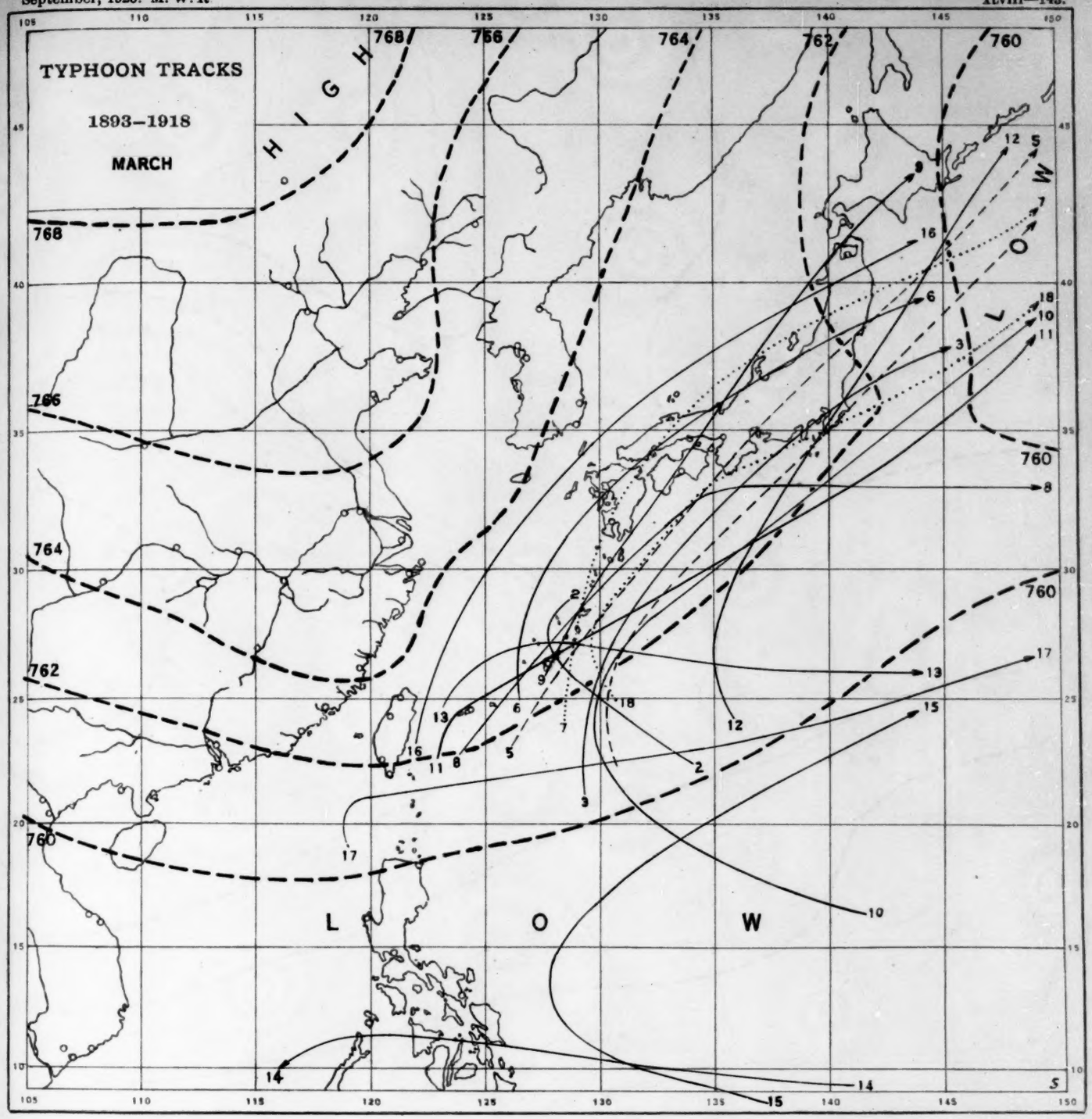


Chart XIV. Weather Map of North Atlantic Ocean, September 30, 1920.

(Plotted by F. A. Young.)





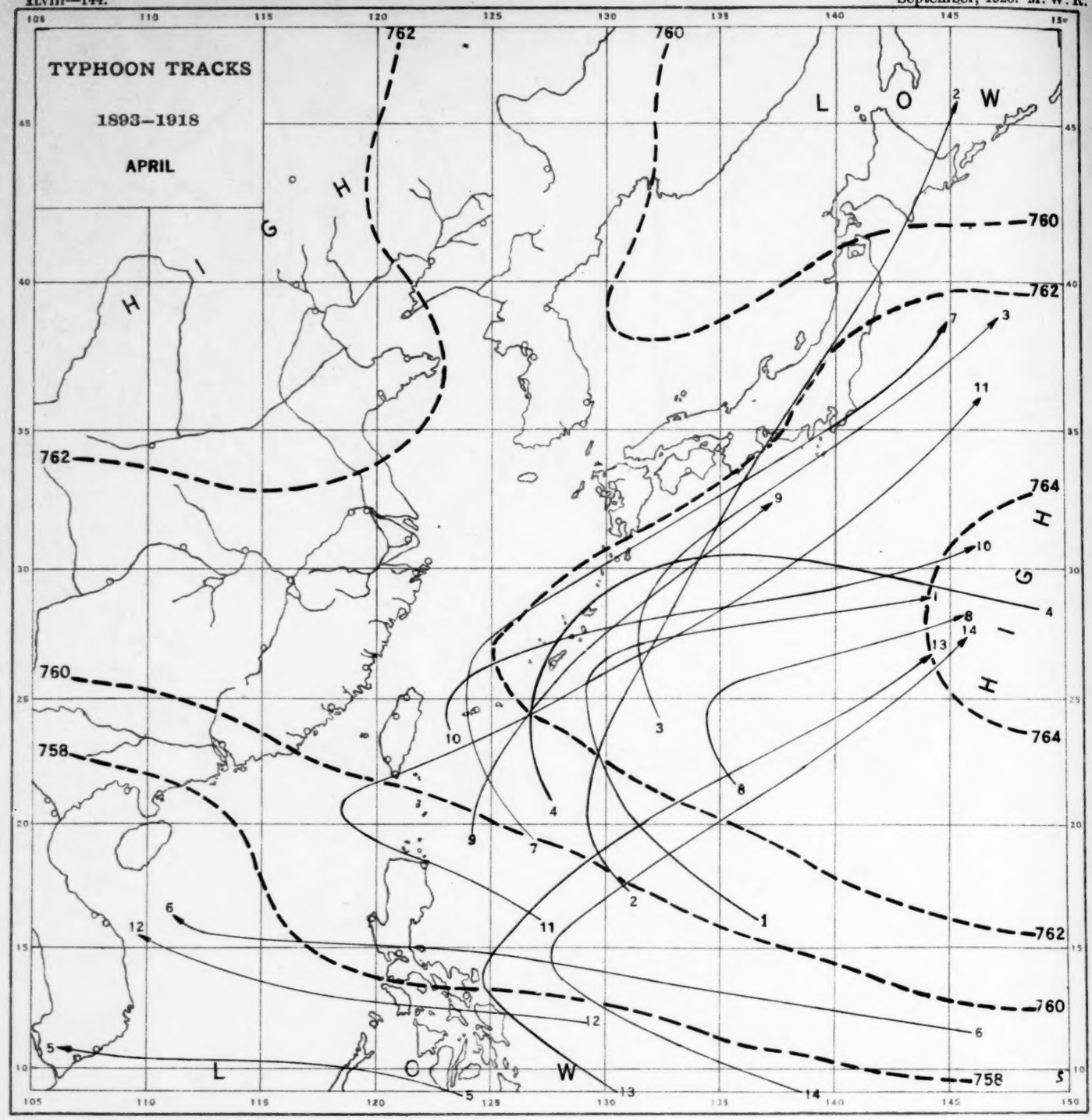
MARCH.—*Single chart: 18 tracks; a little more than two cases in three years.*

Remarks.—The frequency of the occurrences is the same as during February, but there is a distinct change in the grouping of the tracks, which are more dispersed at the beginning, though they continue to come close together at the end. The focus still exists between the Carolines and the Marianas, but much weakened. There is a general advance of the recurving point towards the W., and it is not rare to find it now between Formosa and the Loochoos.

A few tracks sweep straight across the Bonin, but most of them are following higher latitudes to come close near the coast of Japan. One depression has advanced to the middle of the Eastern Sea, and across the SE. part of the Sea of Japan; another is shown in the straits between Formosa and Luzon. But it is still the epoch of calm for the China Sea and practically for the area situated to the NW. of a line joining Formosa to Hokkaïdo. It must be noted during the same period that part of the map is crossed by many continental depressions. It is well to remark that the advance of the tracks westward corresponds to a movement of the isobaric line 764^{mm} from Japan and the Loochoos to the W. part of the Eastern Sea and Korea.

[Reproduced from Atlas of the Tracks of 620 Typhoons, 1893–1918, by Louis Froc, S. J., Director Zi-ka-wei Observatory, Zi-ka-wei–Chang-hai, 1920.]

TYPHOONS IN THE FAR EAST DURING 26 YEARS.



APRIL.—*Single chart: 14 tracks; a little more than one case in two years.*

Remarks.—We are passing through the minimum of the disturbing activity; however, the focus shown in the low latitudes gives signs of increasing energy and begins to throw some centres of depressions across the Philippines, on the China Sea, where they persevere to the close neighborhood of the coasts of Indo-China. One of them deserves a special notice: it was a narrow and violent typhoon which swept over Cape St. James and caused considerable destruction in the Saigon river on the 1st of May, 1904.

Very rare are the oceanic depressions that reach Japan, this month; but on the contrary they show a tendency to converge more to the south towards the Bonin Is., to continue on the Pacific. The recurving points continue their movement of the preceding month westwards, in some instances they have approached the eastern coast of Luzon, and one track has recurved between the Bashi and Ballintang channels not far from the Pratas. This corresponds again with a new retreat of the high pressures on the continent: the isobar 762^{mm} has replaced on the chart, along our coasts, the line 764^{mm}, which has retired as far as Mongolia.

[Reproduced from Atlas of the Tracks of 620 Typhoons, 1893–1918, by Louis Froc, S. J., Director Zi-ka-wei Observatory, Zi-ka-wei–Chang-hai, 1920.]